

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b> <b>C07D 477/00, A61K 31/40</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 95/13278</b> <b>(43) International Publication Date:</b> 18 May 1995 (18.05.95)
<b>(21) International Application Number:</b> PCT/EP94/03686 <b>(22) International Filing Date:</b> 9 November 1994 (09.11.94) <b>(30) Priority Data:</b> 9323137.1 10 November 1993 (10.11.93) GB <b>(71) Applicant (for all designated States except US):</b> GLAXO S.P.A. [IT/IT]; Via Alessandro Fleming, 2, I-37100 Verona (IT). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> PERBONI, Alcide [IT/IT]; Glaxo S.p.A., Via Alessandro Fleming, 2, I-37100 Verona (IT). PENTASSUGLIA, Giorgio [IT/IT]; Glaxo S.p.A., Via Alessandro Fleming, 2, I-37100 Verona (IT). ANDREOTTI, Daniele [IT/IT]; Glaxo S.p.A., Via Alessandro Fleming, 2, I-37100 Verona (IT). WINDERS, John, Alexander [GB/IT]; Glaxo S.p.A., Via Alessandro Fleming, 2, I-37100 Verona (IT). <b>(74) Agents:</b> FILLER, Wendy, Anne et al.; Glaxo Holdings plc, Glaxo House, Berkeley Avenue, Greenford, Middlesex UB6 0NN (GB).		<b>(81) Designated States:</b> AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> UREA DERIVATIVES  <div data-bbox="617 1218 1104 1386"><p style="text-align: right;">(I)</p></div> <b>(57) Abstract</b> <p>Compounds of formula (I), salts and metabolically labile esters thereof; wherein R represents hydrogen or C<sub>1-6</sub>alkyl; R<sub>1</sub> represents hydrogen or C<sub>1-6</sub>alkyl; R<sub>2</sub> represents hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, aryl, cycloalkyl or heterocyclic group, having antibacterial activity and processes.</p>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

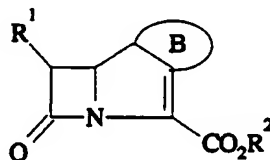
Urea Derivatives

5 This invention relates to urea derivatives having antibacterial activity, to processes for their preparation, to compositions containing them and to their use in medicine.

10 European Patent Application publication No. 0416953A2 describes 10-(1-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylic acid and certain 4 substituted derivatives thereof, which have antibacterial activity.

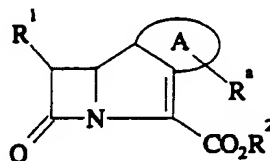
European Patent Application publication No. 0422596A2 describes compound of the general formula

15

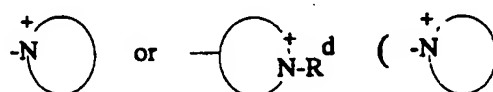


20 wherein R¹ is inter alia a 1-hydroxyethyl group, CO₂R² is a carboxy group which may optionally be esterified and ring B is a cyclic group which may be optionally substituted. Ring B may inter alia be a cyclohexane ring. The compounds have antibacterial activity. The specification specifically teaches compounds wherein B is an unsubstituted cyclohexane ring, but there is no teaching of specific compounds wherein the cyclohexane ring is substituted.

25 European Patent Application No. 0507313A1 describes inter alia compounds of formula



wherein  $R^1$  is inter alia an optionally substituted lower alkyl group,  $CO_2R^2$  is a carboxy group which may be esterified, ring A is inter alia a cyclohexane ring and  $R^a$  is the group  $W^aU^a$  [ $W^a$  is a bond, sulphur (which may be in the form of mono- or dioxide), oxygen, NH (which may be substituted) or a straight-chain or branched lower alkylene or alkenylene group which may be interrupted by sulphur (which may be in the form of mono- or dioxide), oxygen or NH (which may be substituted);  $U^a$  is carbamoyl, acyl which may be substituted, alkylammonium which may be substituted or a group of the formula



10

is a quaternized nitrogen-containing heterocyclic group which may be substituted and  $R^d$  is an alkyl group which may be substituted)] which compounds have antibacterial activity. Preferred compounds of this class are said to be 10-(1-hydroxyethyl)-11-oxo-1-azatricyclo [7.2.0.0<sup>3,8</sup>] undec-2-ene-2-carboxylic acid, derivatives wherein the group  $R^a$  is  $(CH_2)_m K^a(CH_2)_n U^a$  (wherein  $K^a$  is  $CH_2$ , O, S or NH; m and n each is a whole number of 0 to 3; and  $U^a$  is an N-linked quaternary ammonium group.

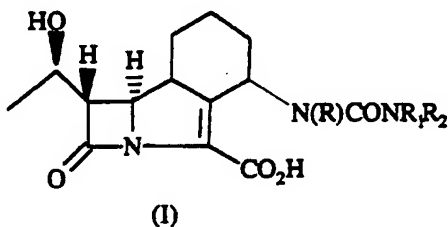
15

We have now discovered that the introduction of certain urea groupings at the 4 position of 10-(1-hydroxyethyl)-11-oxo-1-azatricyclo [7.2.0.0<sup>3,8</sup>] undec-2-ene-2-carboxylic acid provides compounds with a particularly useful profile of activity as antibacterial agents.

20

According to the present invention, therefore we provide compounds of general formula (I)

25



salts and metabolically labile esters thereof;  
wherein R represents hydrogen or C<sub>1-6</sub>alkyl;  
R<sub>1</sub> represents hydrogen or C<sub>1-6</sub>alkyl;  
R<sub>2</sub> represents hydrogen or an optionally substituted, alkyl, alkenyl, alkynyl, aryl,  
5 cycloalkyl or heterocyclic group.

10 In addition to the fixed stereochemical arrangement as defined in formula (I) the molecule contains a further asymmetric carbon atom at the 8-position, and another at the 4-position. It will be appreciated that all stereoisomers including mixtures thereof arising from these additional asymmetric centres, are within the scope of the compounds of formula (I). Compounds of formula (I) may also exist in tautomeric forms and such tautomers and derivatives thereof are also within the scope of the invention

15 Salts of compounds of formula (I) include base addition salts for use in medicine such salts are formed with bases that have a physiologically acceptable cation. Suitable cations include those of alkali metals (e.g. sodium or potassium), alkaline earth metals (e.g. calcium), amino acids (e.g. lysine and arginine) and organic bases (e.g. procaine, phenylbenzylamine, dibenzylethylenediamine,  
20 ethanolamine, diethanolamine, and N-methyl glucosamine).

Salts derived from bases wherein the cation is not physiologically acceptable may be useful as intermediates for the preparation and/or isolation of other compounds of the invention, and these salts also form part of the invention.

25 When the group R<sub>2</sub> contains a basic centre, acid addition salts of such compounds and internal salts formed with the carboxylic acid grouping are also included in the invention.

30 It will be appreciated that the compounds of formula (I) may be produced in vivo by metabolism of a suitable metabolically labile ester. Examples of suitable metabolically labile esters include acyloxyalkyl esters such as, acyloxymethyl or 1-acyloxyethyl e.g. pivaloyloxymethyl, 1-pivaloyloxyethyl, acetoxymethyl, 1-acetoxyethyl, 1-(1-methoxy-1-methyl)ethylcarbonyloxyethyl, 1- benzoyloxyethyl,  
35 isopropoxycarbonyloxymethyl, 1-isopropoxycarbonyloxyethyl,

cyclohexylcarbonyloxymethyl, 1-cyclohexylcarbonyloxyethyl ester,  
 cyclohexyloxycarbonyloxymethyl, 1-cyclohexyloxycarbonyloxyethyl, 1-(4-  
 tetrahydropyranyloxy)carbonyloxyethyl or 1-(4-  
 tetrahydropyranyl)carbonyloxyethyl or 3-phthalidyl.

5

The compound of formula (I) salts thereof and metabolically labile esters thereof may form solvates (e.g. hydrates) and the invention includes all such solvates.

10

When  $R$ ,  $R_1$  and or  $R_2$  are a  $C_{1-6}$ alkyl group they may be a straight or branched group e.g. methyl, ethyl, propyl, isopropyl, butyl, isobutyl, t-butyl, pentyl, isopentyl or hexyl.

15

When  $R_2$  is alkenyl this is a  $C_{3-6}$ alkenyl group which may be a straight or branched chain group e.g. allyl,

20

When  $R_2$  is alkynyl this is a straight or branched chain  $C_{3-6}$  alkynyl group e.g. propargyl.

25

When  $R_2$  is a substituted alkyl, alkenyl or alkynyl group it is substituted by one or more substituents selected from optionally substituted aryl or aryloxy, azido halogen, hydroxy, cyano, nitro, trifluoromethyl, trifluoromethoxy, tri( $C_{1-4}$  alkyl ammonium,  $C_{1-4}$ alkoxy,  $NR_3R_4$  (wherein  $R_3$  and  $R_4$  independently represent hydrogen or  $C_{1-4}$ alkyl),  $NR_3R_6$  (wherein  $R_6$  is acyl),  $COR_5$  (wherein  $R_5$  is hydroxy,  $C_{1-4}$ alkoxy or  $NR_3R_4$ ),  $CO_2R_6$  (wherein  $R_6$  is  $C_{1-4}$ alkoxy or  $NR_3R_4$ ) or  $SO_2R_6$ .

30

The term optionally substituted aryl as a group or part of group when used herein refers to a mono or bicyclic aryl group. Suitable monocyclic aryl groups include phenyl or a 5-6 membered heteroaryl group containing 1 to 3 heteroatoms selected from oxygen, sulphur or nitrogen. Examples of such heteroaryl groups include furanyl, thienyl, imidazolyl, thiazolyl, oxazolyl, pyrazolyl pyridinyl, pyridinium, pyridazinyl, pyrimidinyl or thiadiazolyl. Suitable bicyclo aryl groups contain 9 or 10 ring members selected from carbon, oxygen, sulphur and nitrogen with the proviso that at least 6 are carbon atoms.

Examples of such groups include naphthyl, indenyl, quinoliny, benzofuranyl, benzimidazolyl, benzoxazolyl, indolyl, benzothiazolyl or phthalimidoyl.

5 When  $R_2$  is a heteroaryl group it is attached to nitrogen atom of the urea group via a carbon atom member of the heteroaryl group.

When  $R_2$  is or contains a substituted aryl group it is substituted by one or more groups selected from  $C_{1-4}$ alkyl, halogen, cyano, nitro, trifluoromethyl, trifluoromethoxy, succinimido or  $(CH_2)_nR_7$  wherein n is zero or an integer from 1 to 4 and  $R_7$  is hydroxy,  $C_{1-4}$ alkoxy,  $NR_3R_4$ ,  $NR_3R_8$ ,  $COR_5$ ,  $CO_2R_6$ ,  $SO_2R_6$ , or  $S(O)_mR_9$  wherein m is zero 1 or 2  $R_9$  is  $C_{1-4}$  alkyl or  $R_9$  is the group  $NR_3R_4$  when m is 2.

10

When  $R_2$  is an optionally substituted heterocyclic group this is a carbon linked 5-7 membered saturated heterocyclic group containing a single heteroatom selected from oxygen, sulphur or nitrogen. Examples of such groups include tetrahydropyranyl e.g. 4 tetrahydropyranyl or piperidiny e.g. 4-piperidiny and N-substituted derivative thereof e.g. N-alkyl or N-acyl derivatives.

15

When  $R_2$  is optionally substituted cycloalkyl group it is a  $C_{3-7}$  monocycloalkyl group such as cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl or cycloheptyl which may be substituted by one or more groups selected from  $C_{1-4}$ alkyl halogen, hydroxy, cyano, nitro, trifluoromethyl, trifluoromethoxy or  $(CH_2)_nR_7$ .

20

When  $R_8$  is acyl this may be for example  $C_{1-6}$ alkanoyl, aroyl e.g. benzoyl, or  $C_{1-6}$ alkoxycarbonyl

25

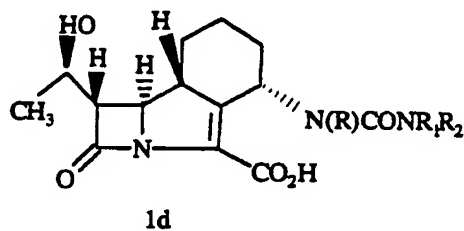
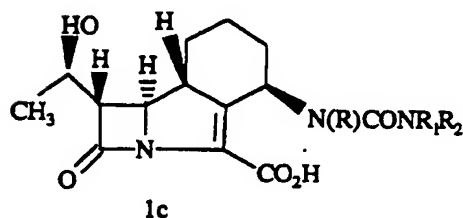
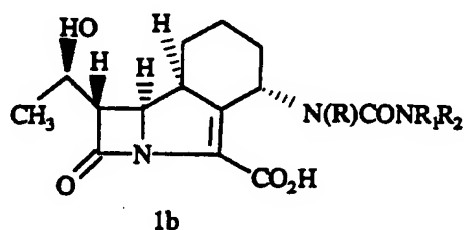
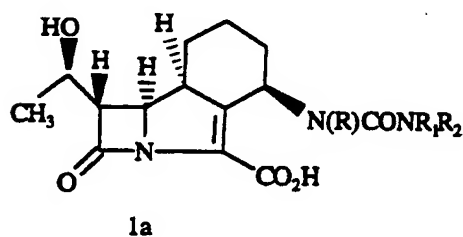
The term halogen when used herein means fluorine, chlorine, bromine or iodine unless otherwise specified.

30

In a further aspect the invention provides compounds of formula (I) wherein R represents hydrogen or  $C_{1-6}$ methyl,  $R_1$  represents hydrogen or  $C_{1-6}$ methyl,  $R_2$  represents an optionally substituted alkyl, aryl, cycloalkyl or phenylalkyl group.

6

The general formula (I) as drawn includes at least 4 stereoisomers and mixtures thereof and these may be represented by the formulae (1a, 1b, 1c and 1d).



5

The solid wedge shaped bond indicates that the bond is above the plane of the paper. The broken bond indicates that the bond is below the plane of the paper.

When  $R_2$  is an optionally substituted alkyl group conveniently this is a  $C_{1-4}$ alkyl group e.g. methyl, ethyl or t butyl optional substituted by a group selected from hydroxy, halo, azido, trimethylammonium,  $COR_5$  wherein  $R_5$  is OH,  $C_{1-4}$ alkoxy or  $NR_3R_4$  (e.g. dimethylamino),  $NR_3R_8$  (e.g. acetyl amino, benzoyl amino, or t-butoxycarbonyl amino), optionally substituted phenyl, optionally substituted phenoxy, optionally substituted pyridyl or 1, 2 oxazolyl. Examples of such  $R_2$  groups include methyl, ethyl, t-butyl, ethyl (substituted by hydroxy, halo e.g. chlorine, azido, dimethylamino, trimethylammonium, carboxy, ethoxycarbonyl),  $C_{1-2}$ alkyl e.g. methyl or ethyl substituted by phenyl (optionally substituted by 1 or 2 groups selected from halogen e.g. chlorine or fluorine, or  $SO_2NR_3R_4$ ), phenoxy, pyridyl, N-methyl pyridinium or 1,2 oxazolyl,

20

When  $R_2$  is an optionally substituted monocyclic aryl group this is conveniently a phenyl group [optionally substituted by 1 to 3 groups selected from  $C_{1-4}$ alkyl e.g. methyl or isopropyl, halo e.g. bromine, chlorine or fluorine, trifluoromethyl, nitro, cyano, hydroxy, alkoxy. e.g. methoxy,  $COR_5$  e.g.  $CO_2H$  or  $CON(CH_3)_2$ ,  $NHR_8$



(e.g.  $\text{CH}_3\text{CONH}$ ), trimethylammonium,  $\text{S(0)}_m\text{CH}_3$ ,  $\text{SO}_2\text{NR}_3\text{R}_4$  e.g.  $\text{SO}_2\text{N(CH}_3)_2$  or succinimido], pyridyl [optionally substituted by halogen e.g. chloride or bromine, trifluoromethyl, phenyl, hydroxy, alkoxy e.g. methoxy, oxo, or alkyl e.g. methyl], N-methylpyridinium, optionally substituted pyrimidinyl e.g. uracilyl, N-methyl uracilyl, N,N-dimethyl uracilyl or 2-thio uracilyl, optionally substituted furyl e.g. furyl or methyl furyl, optionally substituted thienyl e.g. thienyl or methyl-thienyl, pyrrole e.g. N-methylpyrrole, pyrazolyl or 1,5-dimethyl pyrazolyl or thiadiazolyl.

When  $\text{R}_2$  is a heterocyclic group this is conveniently a 4-piperidinyl grouping optionally substituted on the nitrogen atom by or alkyl e.g. propyl, alkanoyl e.g. formyl or acetyl, or allyloxycarbonyl group; or a 4-tetrahydropyranyl group.

Examples of suitable R and  $\text{R}_1$  groups include hydrogen or methyl

Examples of suitable  $\text{R}_2$  groups include hydrogen, methyl, ethyl, t-butyl, allyl, propargyl, azidoethyl, hydroxyethyl, chloroethyl, dimethylaminoethyl, trimethylammonium-ethyl, 1-carboxyethyl, 2-ethoxycarbonyl ethyl, phenoxyethyl, benzomidomethyl, t butyloxycarbonylaminomethyl, benzyl (optionally substituted by chloro and or fluoro, or by aminosulphonyl), phenylethyl, pyridylmethyl, pyridylethyl, N-methylpyridinium-methyl 1,2 oxazolylmethyl, furfuryl, pyridyl, N-methylpyridinium, pyridyl (substituted by 1 or 2 chlorine or bromine atoms, trifluoromethyl, phenyl, or methoxy), N-methyl-2-pyridone, furyl, 2-methylfuryl, thienyl, methylthienyl, N-methylpyrrole, thiadiazolyl, methylthiadiazolyl, uracilyl, N-methyluracilyl, N,N-dimethyluracilyl, cyclohexyl, cyclopropyl, or 4-tetrahydropyranyl, or N-substituted 4-piperidinyl.

A preferred class of compounds of formula I are those in which the carbon atom at the 8- position is in the  $\beta$  configuration. Within this class those compounds in which the carbon atom at the 4- position is in the  $\alpha$  configuration are particularly preferred.

A preferred class of compounds of formula (I) are those wherein R is methyl or hydrogen. A further preferred class of compounds of formula (I) are those wherein  $\text{R}_1$  is hydrogen or methyl.

Compounds of formula (I) wherein one of the groups R, R<sub>1</sub> or R<sub>2</sub> has the meanings defined other than hydrogen represent a further preferred aspect of the invention.

- 5 Preferred R<sub>2</sub> groups include phenyl (optionally substituted by hydroxy, methoxy, cyano, acetamido or methylsulphonyl), pyridyl, pyridylmethyl, phenoxyethyl, furfuryl or uracilyl.

- 10 A preferred group of compounds of formula (I) include those wherein R and R<sub>1</sub> are hydrogen. Within this group those wherein R<sub>2</sub> is phenyl (optionally substituted by hydroxy, methoxy, cyano, acetamido, methylsulphonyl), pyridyl, pyridylmethyl, phenoxyethyl, furanyl or uracilyl are particularly preferred.

Specifically preferred compounds according to the invention include

- 15 (4S,8S,9R,10S,12R)-4-(phenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 (4S,8S,9R,10S,12R)-4-(3"-pyridineaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 20 (4S,8S,9R,10S,12R)-4-[(2"-hydroxyphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 (4S,8S,9R,10S,12R)-4-[(4"-methylsulphonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 25 (4S,8S,9R,10S,12R)-4-(uracil-5'-amino)carbonilamino-10-(1'-hydroxyethyl)-11-oxo-1-aza-tricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylic acid;  
 (4S,8S,9R,10S,12R)-4-(3"-picolylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 30 (4S,8S,9R,10S,12R)-4-(2"-furfurylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 (4S,8S,9R,10S,12R)-4-[(2"-methoxyphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;  
 35 (4S,8S,9R,10S,12R)-4-[(benzylaminocarbonyl)amino]-10-(1'-

hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2- carboxylic acid;  
(4S,8S,9R,10S,12R)-4-[(3"-cyanophenylaminocarbonyl)amino]-10-(1'-  
hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2- carboxylic acid;  
(4S,8S,9R,10S,12R)-4-[(2"-phenoxyethylaminocarbonyl)amino]-10-(1'-  
5 hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2- carboxylic acid;  
(4S,8S,9R,10S,12R)-4-[(4"-acetamidophenylaminocarbonyl)amino]-10-(1'-  
hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2- carboxylic acid;  
(4S,8S,9R,10S,12R)-4-[(4"-cyanophenylaminocarbonyl)amino]-10-(1'-  
hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2- carboxylic acid  
10 and physiologically acceptable salt or metabolically labile ester thereof.

A further preferred compound of the invention is

(4S,8S,9R,10S,12R)-4-(aminocarbonyl-N-methylamino)-10-(1'hydroxyethyl)-11-  
15 oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2ene-2- carboxylic acid and physiologically  
acceptable salt or metabolically labile ester thereof

Compounds according to the invention not only exhibit a broad spectrum of  
antibacterial activity against a wide range of pathogenic microorganisms but  
20 also have a very high resistance to all  $\beta$ -lactamases. Compounds of the  
invention are also relatively stable to renal dehydropeptidase.

Thus using a standard microtiter broth serial dilution test compounds of the  
invention have been found to exhibit useful levels of activity against a wide  
25 range of pathogenic microorganisms including strains of Staphylococcus  
aureus, Streptococcus faecalis, Escherichia coli, Pseudomonas aeruginosa,  
Klebsiella pneumoniae, Proteus mirabilis, Clostridium perfringens and  
Bacteriodes fragilis.

30 Compounds of the invention have also been found to exhibit a particularly  
advantageous serum half life in mice.

The compounds of the invention may therefore be used for treating a variety of  
diseases caused by pathogenic bacteria in human beings and animals.

Thus, according to another aspect of the present invention, we provide a compound of formula (I) or a physiologically acceptable salt thereof for use in the therapy or prophylaxis of systemic or topical bacterial infections in a human or animal subject.

5

According to a further aspect of the invention we provide the use of a compound of formula (I) or a physiologically acceptable salt thereof for the manufacture of a therapeutic agent for the treatment of systemic or topical bacterial infections in a human or animal body.

10

According to a yet further aspect of the invention we provide a method of treatment of the human or non-human animal body to combat bacterial infections which method comprises administering to the body an effective amount of a compound of formula (I) or a physiologically acceptable salt thereof.

15

While it is possible that, for use in therapy, a compound of the invention may be administered as the raw chemical it is preferable to present the active ingredient as a pharmaceutical formulation.

20

The compounds of the invention may be formulated for administration in any convenient way for use in human or veterinary medicine and the invention therefore includes within its scope pharmaceutical compositions comprising a compound of the invention adapted for use in human or veterinary medicine.

25

Such compositions may be presented for use in conventional manner with the aid of one or more suitable carriers or excipients. The compositions of the invention include those in a form especially formulated for parenteral, oral, buccal, rectal, topical, implant, ophthalmic, nasal or genito-urinary use.

30

The compounds according to the invention may be formulated for use in human or veterinary medicine by injection (e.g. by intravenous bolus injection or infusion or via intramuscular, subcutaneous or intrathecal routes) and may be presented in unit dose form, in ampoules, or other unit-dose containers, or in multi-dose containers, if necessary with an added preservative. The

35

compositions for injection may be in the form of suspensions, solutions, or

emulsions, in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilising, solubilising and/or dispersing agents. Alternatively the active ingredient may be in sterile powder form for reconstitution with a suitable vehicle, e.g. sterile, pyrogen-free water, before use.

The compounds of the invention may also be presented for human or veterinary use in a form suitable for oral or buccal administration, for example in the form of solutions, gels, syrups, mouth washes or suspensions, or a dry powder for constitution with water or other suitable vehicle before use, optionally with flavouring and colouring agents. Solid compositions such as tablets, capsules, lozenges, pastilles, pills, boluses, powder, pastes, granules, bullets or premix preparations may also be used. Solid and liquid compositions for oral use may be prepared according to methods well known in the art. Such compositions may also contain one or more pharmaceutically acceptable carriers and excipients which may be in solid or liquid form.

The compounds of the invention may also be administered orally in veterinary medicine in the form of a liquid drench such as a solution, suspension or dispersion of the active ingredient together with a pharmaceutically acceptable carrier or excipient.

The compounds of the invention may also, for example, be formulated as suppositories e.g. containing conventional suppository bases for use in human or veterinary medicine or as pessaries e.g. containing conventional pessary bases.

The compounds according to the invention may be formulated for topical administration, for use in human and veterinary medicine, in the form of ointments, creams, gels, lotions, shampoos, powders, (including spray powders), pessaries, tampons, sprays, dips, aerosols, drops (e.g. eye ear or nose drops) or pour-ons.

Aerosol sprays are conveniently delivered from pressurised packs, with the use of a suitable propellant, eg dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas.

- 5 For topical administration by inhalation the compounds according to the invention may be delivered for use in human or veterinary medicine via a nebuliser.

10 The pharmaceutical compositions for topical administration may also contain other active ingredients such as corticosteroids or antifungals as appropriate.

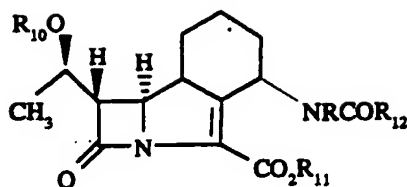
The compositions may contain from 0.01-99% of the active material. For topical administration, for example, the composition will generally contain from 0.01-10%, more preferably 0.01-1% of the active material.

15 For systemic administration the daily dose as employed for adult human treatment will range from 5-100mg/kg body weight, preferably 10-60mg/kg body weight, which may be administered in 1 to 4 daily doses, for example, depending on the route of administration and the condition of the patient. When  
20 the composition comprises dosage units, each unit will preferably contain 200mg to 1g of active ingredient.

The duration of treatment will be dictated by the rate of response rather than by arbitrary numbers of days.

25 The compounds of formula (I) may be prepared from the compounds of formula (II) wherein R is as defined in formula (I) and R<sub>10</sub> is a hydrogen atom or a hydroxyl protecting group and R<sub>11</sub> is hydrogen or a carboxyl protecting group and R<sub>12</sub> is an optionally substituted phenoxy or imidazolyl group or halogen  
30 atom

13

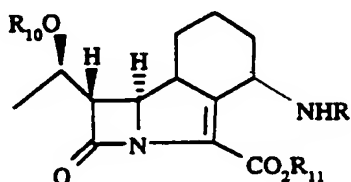


(II)

by reaction with an amine (III;  $R_1R_2NH$ ) wherein  $R_1$  and  $R_2$  have the meanings defined above, followed where necessary or desired by removal of the hydroxyl protecting group  $R_{10}$  and the carboxy protecting group  $R_{11}$ . The reaction is preferably carried out in a solvent such as a halohydrocarbon (e.g. dichloromethane) or an ether (e.g. tetrahydrofuran) or an amide (e.g. N,N-dimethylformamide) or acetonitrile at a temperature with the range of room temperature to the reflux temperature of the solvent and optionally in the presence of a base such as a tertiary amine e.g. triethylamine.

10

In a further process of the invention compounds of formula (I) may be prepared by reaction of the amine (IV) in which R has the meanings defined in formula (I) and  $R_{10}$  and  $R_{11}$  are as defined in formula (II)



(IV)

15



with the isocyanate (V) wherein  $R_2$  has the meanings defined in formula (I) or is a protected derivatives thereof, or the compound (VI) wherein  $R_1$  and  $R_2$  have the meanings defined or are a protected derivative thereof and  $R_{12}$  is an optionally substituted phenoxy or imidazolyl group or halogen followed where necessary or desired by removal of any protecting group.

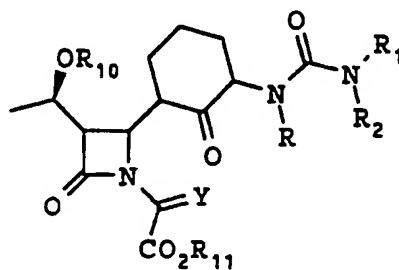
The reaction with the isocyanate (V) is conveniently carried out in a solvent such as tetrahydrofuran or aqueous tetrahydrofuran, a halohydrocarbon (e.g.

25

dichloromethane), or acetonitrile optionally in the the presence of a base such as triethylamine, and at a temperature with the range of 0 - 80°C.

5 The reaction with the compound (VI) is preferably carried out in a solvent such as a halohydrocarbon (e.g. dichloromethane) or an ether (e.g. tetrahydrofuran) or an amide (e.g. N,N-dimethylformamide) at a temperature with the range of room temperature to the reflux temperature of the solvent and optionally in the presence of a base such as a tertiary amine e.g. triethylamine. When the  
10 the reaction is carried out using a compound of formula (VI) wherein R<sub>12</sub> is halogen the reaction is conveniently carried out at a temperature with the range 0-60.

The compounds of formula I wherein R and R<sub>1</sub> are C<sub>1-6</sub> alkyl may be obtained by the cyclisation of a compound of formula (VII)



(VII)

15 Wherin R, R<sub>1</sub> and R<sub>2</sub> have the meaning defined in formula I or are a protected derivatives thereof with the proviso that R<sub>1</sub> and or R are not hydrogen, R<sub>10</sub> and R<sub>11</sub> are as defined in formula (II), Y is an oxygen atom or a phosphine group, and if required or desired  
20 subsequent to any separation into its stereochemical isomers, to one or more of the following operations:

- a) removal of one or more protecting groups
- b) conversion of a compound in which R<sub>11</sub> is hydrogen or a carboxyl protecting group into a salt of an inorganic or organic base, an acid addition  
25 salt thereof or a metabolically labile ester thereof.

The cyclisation of a compound of formula (VII) in which Y is oxygen is conveniently carried out by heating in the presence of an organic phosphite.



The reaction is preferably carried out in a solvent or mixture of solvents at a temperature within the range 60-200°.

5      Suitable solvents include hydrocarbons with an appropriate boiling point, for example aromatic hydrocarbons, such as toluene or xylene.

10      Suitable organic phosphites include acyclic and cyclic trialkylphosphites, triarylphosphites and mixed alkylarylphosphites. Particularly useful organic phosphites are the trialkylphosphites e.g. triethylphosphite or trimethylphosphite.

15      The cyclisation of a compound of formula (VII) in which Y is a phosphine grouping is preferably carried out in a solvent at a temperature between 40-200°C. Suitable solvents include hydrocarbons such as aromatic hydrocarbons, for example xylene or toluene, aliphatic hydrocarbons and halogenated hydrocarbons such as dichloromethane, chloroform and trichloroethane. Examples of suitable phosphine groups are triarylphosphines e.g. triphenyl phosphine or trialkylphosphines e.g. tri-t-butylphosphine.

20      The hydroxyl and carboxyl protecting groups  $R_{10}$  and  $R_{11}$  may be removed by conventional procedures and in any order. More preferably however the hydroxyl protecting group  $R_{10}$  is removed prior to the removal of the carboxyl protecting group. Such removal of the protecting groups is a further feature of the invention.

25      The hydroxyl protecting groups may be removed by well known standard procedures such as those described in Protective Groups in Organic Chemistry, pages 46-119, edited by J.F.W. Mc Omie (Plenum Press, 1973). For example when  $R_{10}$  is a t-butyltrimethylsilyl group, this may be removed by treatment with  
30      tetrabutylammonium fluoride and acetic acid. This process is conveniently carried out in a solvent such as tetrahydrofuran. Similarly when  $R_{10}$  is a 4-nitrobenzyloxycarbonyloxy group this may be removed by treatment with hydrogen and a metal catalyst e.g. palladium on carbon.

The carboxyl protecting group  $R_{11}$  may also be removed by standard processes such as those described in Protective Groups in Organic Chemistry, pages 192-210, edited by J.F.W. Mc Omie (Plenum Press 1973). For example when  $R_{11}$  represents an arylmethyl group this may be removed by conventional  
5 procedures using hydrogen and a metal catalyst e.g. palladium. When the group  $R_{11}$  represents an allyl or substituted allyl group then this is preferably removed by treatment with an allyl acceptor in the presence of tetrakis(triphenylphosphine) palladium and optionally in the presence of triphenylphosphine. Suitable allyl acceptors include sterically hindered amines  
10 such as tertbutylamine, cyclic secondary amines such as morpholine or thiomorpholine, tertiary amines such as triethylamine, aliphatic or cycloaliphatic  $\beta$ -dicarbonyl compounds such as acetylacetone, ethyl acetoacetate or dimedone,  $\alpha$ -alkanoic acids or alkali metal salts thereof such as acetic acid, propionic acid or 2-ethyl hexanoic acid or the potassium or  
15 sodium salt thereof, or 5,5-dimethyl-1,3-cyclohexadiene.

A particularly useful allyl acceptor is 5,5-dimethyl 1,3-cyclohexadiene.

20 The reaction is preferably carried out in an inert solvent such as an ether e.g. diethyl ether or tetrahydrofuran, an alkanol e.g. ethanol, an ester e.g. ethyl acetate or a halohydrocarbon e.g. methylene chloride, or mixtures thereof. The reaction is conveniently carried out in the temperature range 0°-40° more particularly at room temperature.

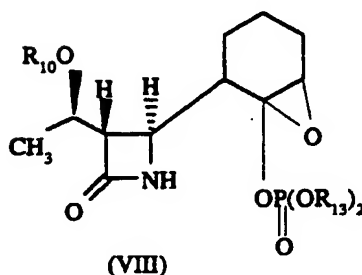
25 Compounds of the invention in which the group  $R_{11}$  is a physiologically acceptable cation may be prepared from compounds of the invention in which  $R_{11}$  is hydrogen by treatment with a suitable base. Conveniently the salt is formed in solution and then if required precipitated by the addition of a non-solvent e.g. a non polar aprotic solvent. Alternatively the sodium or potassium  
30 salt may be prepared by treating a solution of a compound of formula (II) in which  $R_{11}$  represents a hydrogen atom with a solution of sodium or potassium 2-ethylhexanoate in a non-polar solvent such as diethyl ether.

35 Compounds of formula (IV) are either known or may be prepared according to the processes described in EPA No. 0416953A2 or WO 92/15586.

17

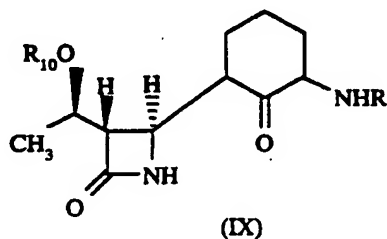
Compounds of formula (II) may also be prepared by analogous methods to those described in EPA No. 0416953A2 and WO 92/15586 . Thus reaction of the epoxide (VIII)

5



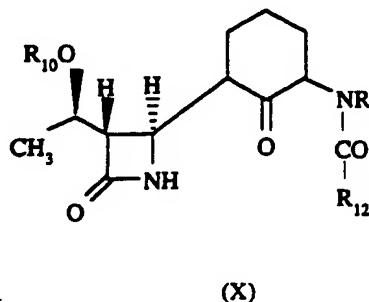
wherein  $R_{10}$  is hydroxyl protecting group and  $R_{13}$  is  $C_{1-4}$ alkyl, with ammonia or the amine  $RNH_2$  wherein  $R$  is as defined in formula (I) gives the amino derivative (IX)

10



Reaction of the amino compound (VIII) with the appropriate chloroformate  $R_{12}COCl$  wherein  $R_{12}$  is an optionally substituted phenoxy group in the presence of a base such as pyridine, lutidine or triethylamine yields the corresponding carbamate (X)

15



The compound (X) may be converted into the compound of formula (II) using the general procedures described in EPA NO. 0416953A2.

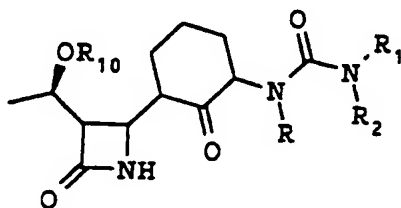
5 In the above reaction when it is necessary or desirable to use a hydroxyl protecting group  $R_{10}$  suitable hydroxyl protecting groups include trialkylsilyl e.g. trimethylsilyl or t-butyldimethylsilyl.

10 Suitable carboxyl protecting groups  $R_{11}$  for use in the above reactions include arylmethyl groups such as benzyl, p-nitrobenzyl t-butylbenzyl or trityl, allyl or substituted allyl groups or trialkylsilylalkyl e.g. trimethylsilyl ethyl.

15 In the above processes for preparing the compounds of the invention via the compounds of formula (II) or (IV) it may also be necessary to protect reactive groups in the amine  $R_1R_2NH$ , or the isocyanate  $R_2NCO$ . Thus if  $R_2$  contains a primary or secondary amino group or a hydroxyl group it may be necessary to protect this group in a conventional manner e.g. as an, allyloxycarbonyl or a trimethylsilyl derivative thereof.

20 The various protecting groups may be removed in a conventional manner.

25 Compounds of formula (VII) in which  $Y=O$  may be prepared by treating a compound of formula (XI) in which the groups  $R_{10}$ ,  $R$ ,  $R_1$ ,  $R_2$  have the meanings given above with an activated derivative of the acid (XII) in which  $R_{11}$  is a carboxyl protecting group.



(XI)



(XII)

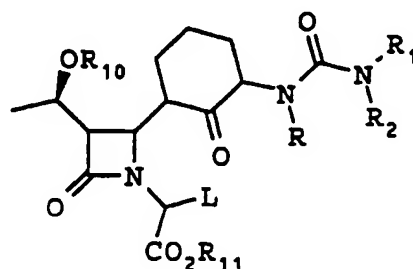
Suitable activated derivatives of the acid (XII) includes the corresponding acid halides e.g. acid chloride.

19

When the acid halide is used as the activated derivative of the acid (XII) then the reaction is preferably carried out in the presence of an acid acceptor such as a tertiary organic base for example pyridine or a trialkylamine in an aprotic solvent such as dichloromethane.

5

The compound of formula (VII) in which Y is a phosphine group may be prepared by treating the intermediate (XIII) in which L is a leaving group such as a halogen e.g. chlorine.



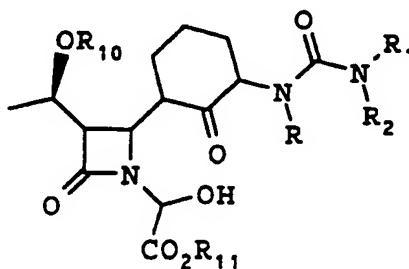
(XIII)

10

with the corresponding phosphine e.g. triphenylphosphine in the presence of a base. The reaction is conveniently carried out in a solvent such as dioxan in the presence of a tertiary organic base, e.g. 2,6 lutidine.

15

The compounds of formula (XIII) may be prepared from the corresponding hydroxy derivative (XIV) by conventional means for converting hydroxyl groups into leaving groups.

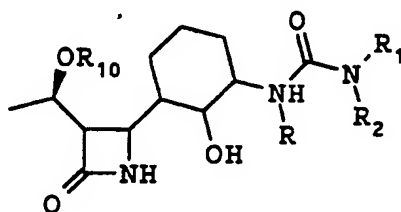


(XIV)

20

Thus for example a compound of formula (XIII) in which L is a chlorine atom may be prepared by treating a compound of formula (XIV) with thionyl chloride in an aprotic solvent such as dioxan or tetrahydrofuran and in the presence of a tertiary organic base e.g. 2,6-lutidine. Compounds of formula (XIV) may be prepared from the reaction of a compound of formula (XI) with glyoxylic ester (XV;  $\text{CHOCO}_2\text{R}_{11}$ ) preferably in the form of its hydrate or hemiacetal. The reaction is preferably carried out in an aprotic solvent such as toluene and in the presence of an activated molecular sieve.

The compound of formula (XI) may be prepared by oxidation of compound of formula (XVI)



(XVI)

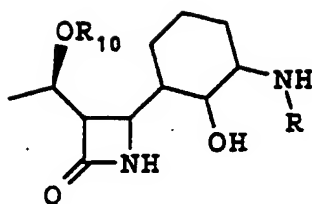
wherein  $\text{R}_2$  is the meanings defined in formula (I) or is a protecting derivatives thereof. , R and  $\text{R}_1$  are C1-6 alkyl group.

The oxidation may be carried out using conventional oxidising agents known in the art for converting a secondary alcohol such as cyclohexanol into a ketone such as cyclohexanone.

Thus for example the reaction may be carried out using oxalyl chloride and dimethylsulphoxide in a solvent such as methylene chloride.

The compounds of formula (XVI) may be prepared by reaction of compounds of formula (XVII) wherein  $\text{R}_{10}$  is defined as in formula (X)

21



(XVII)

with carbamoyl chloride  $\text{ClCONR}_1\text{R}_2$  where in the  $\text{R}_1$  is C1-6 alkyl and  $\text{R}_2$  is defined as in formula I

5

Compounds of formula (XVII) are either known or may be prepared according to the processes describing in EPA No. O416953A2 or WO 92/15586

10 In any of the formulae (I) to (XVII) shown above when there is an asymmetric carbon atom and no specific configuration is shown then the formula includes all possible configurations.

15 Specific stereoisomers of the compounds of formula (I) as defined in formulae 1a, 1b, 1c and 1d, essentially free of the other stereoisomers may be prepared by using the general processes described above starting with the appropriate stereoisomer of formula (II) or (IV).

The processes described above for preparing the compounds of formula (II) will in general give a mixture of stereoisomers.

20

The individual stereoisomers of the compounds of formula (II) may be prepared using the processes described above starting with the appropriate stereoisomer of formula (V).

25 In order that the invention may be more fully understood the following examples are given by way of illustration only.

In the Preparations and Examples, unless otherwise stated:

Infrared spectra were measured in chloroform-d<sub>1</sub> solutions on a FT-IR instrument. Proton Magnetic Resonance (1H-NMR) spectra were recorded at 300 MHz as solutions in D<sub>2</sub>O. Chemical shifts are reported in ppm downfield (δ) from Me<sub>4</sub>Si, used as an internal standard. Temperatures are in 0°C.

5

#### Intermediate 1

Benzyl-(4S,8S,9R,10S,12R)-4-[(N-allyloxycarbonyl-N-methyl)amino]-10-[(1'-t-butyl)dimethylsilyloxy]ethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

- 10 To a solution of (3S,4R)-3-[R-1-(t-butyl)dimethylsilyloxy]ethyl]-4-[(2'S,6'R)-2'-(N-allyloxycarbonyl-N-methylamino-1'-oxocyclohex-6-yl)]azetidin-2-one (12g) in anhydrous methylene chloride (120ml) potassium carbonate (7.5g) and pyridine (5.9ml) were added under nitrogen atmosphere. The mixture was cooled to 0°C, then a solution of benzyl oxalylchloride (10.9g) in anhydrous methylene chloride
- 15 (30ml) was dropped. After 3 hrs the mixture was poured into a cold saturated sodium hydrogen carbonate solution (100ml) and then extracted with ethyl acetate (250ml). The organic layer was washed with a cold solution of ammonium chloride (100ml) and brine (50ml), then it was dried and evaporated under reduced pressure. The crude was purified by flash chromatography
- 20 (eluant: cyclohexane/ethyl acetate 7:3) to give an oil (16g) which was dissolved in nonane (300ml). Triethylphosphite (27.8ml) was added and the solution was refluxed overnight. After cooling to room temperature, 5% hydrogen peroxide solution (250ml, 5% solution) was added, the mixture was stirred for 3 hrs then extracted with ethyl acetate (200ml). The organic layer was washed with H<sub>2</sub>O
- 25 (100ml), brine (50ml), then dried and evaporated under reduced pressure. After flash chromatography (eluant: cyclohexane/ethyl acetate 7:3) the title compound was obtained (10g) as a yellow oil.

#### Intermediate 2

- 30 Benzyl-(4S,8S,9R,10S,12R)-4-methylamino-10-[(1'-t-butyl)dimethylsilyloxy]ethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

- Intermediate 1 (2g) was dissolved in anhydrous methylene chloride (25ml) under nitrogen atmosphere and cooled to 0°C. N,N-dimethyltrimethylsilylamine (1.7ml), trimethylsilyl trifluoroacetate (1.8ml) and a suspension of palladium
- 35



tetrakis(triphenylphosphine) (0.200g) in anhydrous methylene chloride (1ml) were added. After 15 min. the mixture was poured into a saturated sodium hydrogen carbonate solution (20ml) and extracted with ethyl acetate (100ml). The organic layer was dried and evaporated under reduced pressure. The crude  
5 was purified by flash chromatography (eluant ethyl acetate) to give the title compound (1.2g) as a yellow oil.

### Intermediate 3

Benzyl-(4S,8S,9R,10S,12R)-4-[(N-chlorocarbonyl-N-methyl)amino]-10-[(1'-t-butyl)dimethylsilyloxy]ethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-  
10 carboxylate

A solution of intermediate 2 (0.500g) in anhydrous methylene chloride (10ml) under nitrogen atmosphere was cooled to -50°C, then a solution of phosgene (0.75ml of a solution 1.93M in toluene) and triethylamine (0.440ml) in anhydrous  
15 methylene chloride (4ml) was dropped. After 2 hrs at -50°C the reaction was quenched with a cold saturated sodium hydrogen carbonate solution (20ml) and extracted with ethyl acetate (50ml). The organic layer was dried and evaporated under reduced pressure. After flash chromatography (eluant: cyclohexane/ethyl acetate 7:3) the title compound was obtained (0.430g) as a yellow oil.

### Intermediate 4

Benzyl-(4S,8S,9R,10S,12R)-4-[N-[(N-benzyl-N-methyl)aminocarbonyl]-N-methyl]amino-10-[(1'-t-butyl)dimethylsilyloxy]ethyl]-11-oxo-1-  
20 azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

To a solution of intermediate 2 (0.400g) in anhydrous toluene (20ml) triethylamine (0.160ml) and benzylmethylcarbamoyl chloride (0.395g) were added. The mixture was warmed to 80°C for 24 hrs, then poured into a saturated ammonium chloride solution (50ml) and extracted with ethyl acetate (100ml). The organic layer was washed with a saturated sodium hydrogen carbonate  
25 solution (50ml) and brine (50ml), then dried and evaporated under reduced pressure. The crude was purified by flash chromatography (eluant: cyclohexane/ethyl acetate 7:3) to give the title compound (0.120g) as a yellow oil.

### Intermediate 5

Benzyl-(4S,8S,9R,10S,12R)-4-[N-[(N-benzyl-N-methyl)aminocarbonyl]-N-methylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

5 To a solution of intermediate 4 (0.340g) in anhydrous tetrahydrofuran (20ml) acetic acid (0.185ml) and tetrabutylammonium fluoride (2.16ml of a 1M solution in tetrahydrofuran) were added. The solution was stirred at room temperature for 4 days, then diluted with ethyl acetate (150ml) and washed with a saturated sodium hydrogen carbonate solution (50ml) and brine (50ml). The organic layer was dried and evaporated under reduced pressure. The crude was purified by  
10 flash chromatography (eluant: cyclohexane/ethyl acetate 1:1) to give the title compound (0.225g) as a white solid.

Intermediate 6

Benzyl-(4S,8S,9R,10S,12R)-4-[N-[N-(2-pyridyl)-N-methylaminocarbonyl]-N-methylamino-10-[(1'-t-butyl)dimethylsilyloxy]ethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

15 To a solution of intermediate 2 (0.300g) in anhydrous toluene (20ml) triethylamine (0.340ml) and 2-pyridylmethylcarbonyl chloride (0.210g) were added. The mixture was warmed to 40°C for 7 hrs and at room temperature over  
20 night, then poured into a saturated ammonium chloride solution (50ml) and extracted with ethyl acetate (100ml). The organic layer was washed with a saturated sodium hydrogen carbonate solution (50ml) and brine (50ml), then dried and evaporated under reduced pressure. The crude was purified by flash chromatography (eluant: cyclohexane/ethyl acetate 1:1) to give the title compound  
25 compound (0.240g) as a yellow oil.

Intermediate 7

Benzyl-(4S,8S,9R,10S,12R)-4-[N-[N-(2-pyridyl)-N-methylaminocarbonyl]-N'-methylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

30 To a solution of intermediate 6 (0.230g) in anhydrous tetrahydrofuran (20ml) acetic acid (0.130ml) and tetrabutylammonium fluoride (0.470g in 2ml of tetrahydrofuran) were added. The solution was stirred at room temperature for 4 days, then diluted with ethyl acetate (150ml) and washed with a saturated sodium  
35 hydrogen carbonate solution (50ml) and brine (50ml). The organic layer was

dried and evaporated under reduced pressure. The crude was purified by flash chromatography (eluant: ethyl acetate) to give the title compound (0.110g) as a white solid.

IR (CDCl<sub>3</sub>)  $\nu_{\max}$  cm<sup>-1</sup>: 3408, 1717.

5

Intermediate 8

Benzyl-(4S,8S,9R,10S,12R)-4-[N-[N-2-(2-pyridylethyl)-N'-methylaminocarbonyl]-N-methyl]amino-10-[(1'-t-butylidimethylsilyloxy)ethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

10 To a solution of intermediate 3 (0.180g) in anhydrous methylene chloride (10ml) triethylamine (0.045ml) and 2-(2-methylaminoethyl)pyridine (0.045ml) were added. The mixture was stirred overnight at room temperature then quenched with a saturated ammonium chloride solution (10ml) and extracted with ethyl acetate (50ml). The organic layer was dried and evaporated under reduced pressure. The crude was purified by flash chromatography (eluant: cyclohexane/ethyl acetate 2:8) to give the title compound (0.200g) as a yellow oil.

15

Intermediate 9

20 Benzyl-(4S,8S,9R,10S,12R)-4-[N-[N-2-(2-pyridylethyl)-N-methylaminocarbonyl]-N'-methyl]amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

To a solution of intermediate 8 (0.195g) in anhydrous tetrahydrofuran (20ml) acetic acid (0.105ml) and tetrabutylammonium fluoride (0.370g in 2ml of tetrahydrofuran) were added. The solution was stirred at room temperature for 4 days, then diluted with ethyl acetate (150ml) and washed with a saturated sodium hydrogen carbonate solution (50ml) and brine (50ml). The organic layer was dried and evaporated under reduced pressure. The crude was purified by flash chromatography (eluant: ethyl acetate) to give the title compound (0.120g) as a white solid.

25

30

<sup>1</sup>H-NMR (300MHz, CDCl<sub>3</sub>): 8.52 (d), 7.59 (td), 7.45 (d), 7.40-7.10 (m), 5.37 (d), 5.22 (d), 5.01 (t), 4.24 (m), 4.09 (dd), 3.66 (m), 3.18 (dd), 3.04 (t+m), 2.90 (s), 2.48 (s), 2.30-1.20 (m), 1.33 (d).

35 MS (VGquattro-FAB-NBA) m/z: 533.

Intermediate 10

Benzyl (4S,8S,9R,10S,12R) 4-[(N-allyloxycarbonyl-N-methyl)amino]-10-[1'-hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

5 Acetic acid (3.32ml) and tetrabutylammonium fluoride trihydrate (12.2g) were added to a solution of intermediate 1 (5.5g) in distilled tetrahydrofuran (250ml) under a nitrogen atmosphere. The resulting solution was stirred at 23° for 18h, then diluted with ethyl acetate (500ml) and washed with a saturated sodium hydrogen carbonate solution (400ml) and brine (400ml). The organic layer was  
10 dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo* to an oil which was purified by flash chromatography, eluting with cyclohexane/ethyl acetate 3:7, to give the title compound (2.6g) as a pale yellow oil.

IR (CDCl<sub>3</sub>)  $V_{\max}$  cm<sup>-1</sup>: 1774, 1720 and 1691 (C=O)

15 Intermediate 11

Benzyl (4S,8S,9R,10S,12R) 4-[(N-allyloxycarbonyl-N-methyl)amino]-10-[1'-(4-nitrobenzyloxycarbonyl)hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

4-Dimethylaminopyridine (184mg) and 4-nitrobenzylchloroformate (296mg)  
20 were added to a solution of intermediate 10 (640mg) in dry dichloromethane (35ml) under a nitrogen atmosphere. The solution was stirred at 23° for 1h, then further 4-dimethylaminopyridine (368mg) and 4-nitrobenzylchloroformate (592mg) were added. The reaction mixture was stirred at 23° for 1h, then diluted with ethyl acetate (100ml) and washed with saturated ammonium chloride solution  
25 (70ml), saturated sodium hydrogen carbonate solution (70ml) and brine (70ml). The organic layer was dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo* to an oil, which was purified by flash chromatography, eluting with cyclohexane/ethyl acetate 6:4, to give the title compound (700mg) as a white foam.

IR (CDCl<sub>3</sub>)  $V_{\max}$  cm<sup>-1</sup>: 1774, 1749 and 1713 (C=O)

30

Intermediate 12

Benzyl (4S,8S,9R,10S,12R) 4-methylamino-10-[1'-(4-nitrobenzyloxycarbonyl)hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

A solution of intermediate 11 (700mg) in dry dichloromethane (8ml) was cooled to 0°, then N,N-dimethyltrimethylsilylamine (0.52ml), trimethylsilyl trifluoroacetate (0.56ml) and a suspension of palladium tetrakis triphenylphosphine (64mg) in dry dichloromethane (1ml) were added under a nitrogen atmosphere.

The mixture was stirred at 0° for 30min, then diluted with ethyl acetate (20ml) and washed with a saturated sodium hydrogen carbonate solution (20ml) and brine (20ml). The organic phase was dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo*; the residue was purified by flash chromatography eluting with ethyl acetate/methanol 98:2 to give the title compound (360mg) as a white foam.

#### Intermediate 13

Benzyl (4S,8S,9R,10S,12R) 4-[(N-chlorocarbonyl-N-methyl)amino]-10-[1'-(4-nitrobenzyloxycarbonyl)hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

A solution of intermediate 12 (320mg) and triethylamine (0.25ml) in dry dichloromethane (5ml) was added to a 1.93M solution of phosgene in toluene (0.47ml) previously cooled to -78° under a nitrogen atmosphere. The resulting solution was stirred at -50° for 1h, then diluted with ethyl acetate (15ml) and washed with saturated sodium hydroxide solution (15ml) and brine (15ml). The organic layer was dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo*; the residue was purified by flash chromatography, eluting with cyclohexane/ ethyl acetate 4:6, to give the title compound (0.2g) as a yellow oil.

IR (nujol)  $V_{\max}$  cm<sup>-1</sup>: 1780 and 1734 (C=O)

#### Intermediate 14

Benzyl (4S,8S,9R,10S,12R) 4-[N-[(1"-S-benzyloxycarbonyl)ethyl]carbamoyl]-(N-methyl)amino-10-[1'-(4-nitrobenzyloxycarbonyl)hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

Triethylamine (0.093ml) and L-alanine benzyl ester (69mg) were added to a solution of intermediate 13 (195mg) in dry dichloromethane (5ml) under a nitrogen atmosphere. The resulting mixture was stirred at 23° for 24h, then diluted with ethyl acetate (20ml) and washed with a saturated ammonium chloride solution (20ml) and brine (20ml). The organic layer was dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo*; the residue was purified by flash chromatography,

eluting with cyclohexane/ethyl acetate 2:8, to give the title compound (175mg) as colourless oil.

IR (CDCl<sub>3</sub>)  $V_{\max}$  cm<sup>-1</sup>: 1745, 1645 (C=O); 1603 (C=C)

#### 5 Intermediate 15

(3S,4R)-3-[(R)-1-(t-butyldimethylsilyloxy)ethyl]-4-[(R)-2'-((S)-6'-[N-[(N'-methyl-N'-phenyl)aminocarbonyl]-N-methylamino-1'-hydroxycyclohexyl]-azetidin-2-one

To a solution of intermediate (3S,4R)-3-[R-1-(t-butyldimethylsilyloxy)ethyl]-4-  
10 [(2'S,6'R)-2'-(N-allyloxycarbonyl-N-methylamino-1'-hydroxycyclohex-6-yl)]azetidin-2-one ( 1.437 g ) in dichloromethane ( 55 ml ) a room temperature triethylamine ( 0.90 ml ) and N-methyl-N-phenylcarboxy chloride ( 800 mg ) were added .

The reaction mixture was left at room temperature for 48h, then the it was  
15 poured into ammonium chloride solution . The organic phase was washed with brine ( 3x100 ml ) and the solvent removed under vacuo to give the crude material which was purified by flash chromatography to give the title compound ( 1.72 g ).IR ( nujol) cm<sup>-1</sup>: 1745, 1628, 1595. <sup>1</sup>H-NMR ( 300MHz, D<sub>2</sub>O ): 7.35 (t), 7.14 (t), 7.12 (d), 5.89 (bs), 4.30 (m), 4.00 (td), 3.97 (dd), 3.95 (d), 3.78 (m), 3.23 (s), 3.19 (d), 2.40 (s), 2.23 (m), 1.69 (m), 1.6-1.3 (m), 1.35 ( d), 0.91 (s),  
20 0.12 (s). MS (FAB(+))NBA m/z: 490

#### Intermediate 16

3(3S,4R)-3-[(R)-1-(t-butyldimethylsilyloxy)ethyl]-4-[(R)-2'-((S)-6'-[N-[(N'-methyl-N'-phenyl)aminocarbonyl]-N-methylamino-1'-oxocyclohexyl]-azetidin-2-one

25 To a solution of oxalyl chloride ( 1.23 ml ) in dry dichloromethane ( 150 ml ) at -78°C

dimethyl sulfoxide ( 2.0 ml ) in dry dichloromethane ( 40 ml ) was added; after  
15 min. , a solution of intermediate 15 ( 1.7 g ) in dry dichloromethane ( 40 ml ) was added and the resulting mixture was left under stirring at -78°C. After 15  
30 min. triethylamine ( 5.34 ml ) was added and the reaction mixture warm up to 0°C, poured into a saturated ammonium chloride solution and extracted with ethyl acetate. The organic phase was washed with brine ( 3x100 ml ) and the solvent removed under vacuo to give the the title compound ( 1.67 g ).IR ( CDCl<sub>3</sub>) cm<sup>-1</sup>: 1757, 1718, 1653.

Intermediate 17

Allyl-(4S,8S,9R,10S,12R)-4-[N-[(N'-methyl-N'-phenyl)aminocarbonyl]-methylamino]-10-(1'dimethyl-t-butyloxy)silyloxy)ethyl-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-carboxylate

- 5 To a solution of intermediate 16 ( 0.980 g ) in dry dichloromethane ( 15 ml ) at 0°C , solid potassium carbonate, allyloxalyl chloride ( 0.47 ml ) and pyridine ( 0.28 ml ) were added and the resulting mixture was left under stirring at 20°C. A further amount of allyloxalyl chloride ( 0.47 ml ) and pyridine ( 0.28 ml ) were added until complete reaction , then potassium carbonate was filtered off and
- 10 the reaction mixture was washed with a 1% hydrogen chloride cold solution, the saturated sodium hydrogen carbonate and brine. The solvent was removed under vacuo to give the crude compound which was purified by flash chromatography on silica gel, to give the title compound ( 0.90 g ).
- 15 Intermediate 4 ( 0.90 g ) was dissolved in xylene ( 30 ml ) and triethyl phosphite ( 1.3 ml ) was added and the resulting mixture was left under stirring at 140°C for 14 h. The reaction mixture was concentrated under vacuo to give the crude compound which was purified by flash chromatography on silica gel, to give the title compound ( 0.21 g ).
- IR ( CDCl<sub>3</sub> ) cm<sup>-1</sup>: 1767, 1728, 1641, 1597.

20

Intermediate 18

5Allyl-(4S,8S,9R,10S,12R)-4-[N-[(N'-methyl-N'-phenyl)aminocarbonyl]-methylamino]-10-(1'hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-carboxylate

- 25 To a solution of intermediate 17 ( 0.210 g ) in dry THF ( 19 ml ) at 20°C , acetic acid ( 0.116ml ) and tetrabutylammonium fluoride ( 1M solution in THF )( 1.5 ml ) were added and the resulting mixture was left under stirring at 20°C for 60h. The reaction mixture was washed with a saturated sodium hydrogen carbonate solution ( 3x50 ml), ammonium chloride solution ( 3x 50 ml ) and brine ( 3x 50 ml )
- 30 ). The solvent was removed under vacuo to give the crude compound which was purified by flash chromatography on silica gel, to give the title compound ( 0.10 g ).
- IR ( CDCl<sub>3</sub> ) cm<sup>-1</sup>: 1769, 1720, 1643.

35

Intermediate 19

(4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid

#### Intermediate 20

5 (4S,8S,9R,10S,12R)-4-N-methylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid

#### Example 1

10 Sodium - (4S,8S,9R,10S,12R)- 4 - ( phenylaminocarbonylamino) - 10 - (1'-hydroxyethyl) -11- oxo-1- azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate  
 (4S,8S,9R,10S,12R)- 4 - amino) - 10 - (1'-hydroxyethyl) -11- oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (110mg) was dissolved at 0°. in a mixture of tetrahydrofuran (3.5 ml) and 0.025M, pH=7 sodium phosphate buffer solution (6.5 ml) . Phenyl isocyanate ( 2 ml ) was added and the mixture stirred for 15min . The solid diphenylurea was filtered . The aqueous solution was washed three times with ethyl acetate ( 10 ml ) , evaporated to reduce its volume ( 2ml ) then passed through a reverse phase column ( techoprep 40-63 C18 ) . The title compound (70mg) was obtained by  
 15 freeze drying the fraction eluted with a 10% solution of acetonitrile in water .  
 IR (nujol) Vmax cm-1: 1653 (C=O), 1749 (C=O B-lactam);  
 1H-NMR (300 MHz, D2O): 7.22(t), 7.15(m), 7.01(t), 5.17(m), 4.07(m), 4.01(dd), 3.23(dd), 3.03(m), 1.85(m), 1.78(m), 1.7-1.5(m), 1.3-1.16(m) and 1.12(d) ppm .  
 MS (VGquattro-FAB(+)-NBA) m/z : 408

#### Example 2

Sodium-(4S,8S,9R,10S,12R)-4-[(4"-methoxyphenylaminocarbonyl)amino ]-10 - (1'-hydroxyethyl) -11- oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2- carboxylate

30 To a solution of (4S,8S,9R,10,12R) 4 amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup> ] undec-2-ene-2-carboxylic acid (70mg) in dry tetrahydrofuran (6ml) , triethylamine ( 0.15 ml) was added under nitrogen at 22°. The solution was stirred for 10min, then p-methoxyphenyl isocyanate (0.1ml) was added. The obtained mixture was stirred for 15min then filtered over celite . A 0.5M solution of sodium-2-ethylhexanoate in tetrahydrofuran (0.6 ml)  
 35 was added to the filtrate. After 10min the tetrahydrofuran solution was partially



concentrated and treated with diethylether to give a solid which was centrifuged washed with ethyl acetate/diethylether 8/2 and dried to afford a white solid (65mg). The solid was dissolved in water, washed three times with ethyl acetate (10 ml), then passed through a reverse phase column (techoprep 40-63 C18). The title compound (20 mg) was obtained by freeze drying the fraction eluted with a 10% solution of acetonitrile in water.

IR (nujol) Vmax cm<sup>-1</sup>: 1664 (C=O), 1750 (C=O B-lactam);

<sup>1</sup>H-NMR (300 MHz, D<sub>2</sub>O): 7.05 (m), 6.82(m), 5.14(m), 4.07(m), 3.98(dd), 3.67(s), 3.24(dd), 3.03(m), 1.84(m), 1.76(m), 1.68-1.50(m), 1.22(m) and 1.12(d) p.p.m.

MS (VGquattro-FAB(+))NBA) m/z : 438

### Example 3

Sodium-(4S,8S,9R,10S,12R)-4-[(4'-fluorophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

To a solution of (4S,8S,9R,10S,12R) 4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylic acid (75mg) in dry tetrahydrofuran (6ml), triethylamine (0.17 ml) was added under nitrogen at 22<sup>o</sup>. The solution was stirred for 10min, then p-fluorophenyl isocyanate (0.1ml) was added. The obtained mixture was stirred for 15min then a 0.5M solution of sodium-2-ethylhexanoate in tetrahydrofuran (0.6 ml) was added. The tetrahydrofuran solution was partially concentrated and treated with diethylether to give a solid which was centrifuged washed with ethyl acetate/diethylether 8/2 and dried to afford title compound (47mg) as a white solid.

IR (nujol) Vmax cm<sup>-1</sup>: 1672 (C=O), 1750 (C=O B-lactam);

<sup>1</sup>H-NMR (300 MHz, D<sub>2</sub>O): 7.10 (m), 6.94(m), 5.14(m), 4.07(m), 3.98(dd), 3.24(dd), 3.03(m), 1.90-1.70(m), 1.68-1.46(m), 1.30-1.14(m) and 1.12(d) p.p.m.

MS (VGquattro-FAB(+))NBA) m/z : 426.

### Example 4

Sodium-(4S,8S,9R,10S,12R)-4-(benzylmethylaminocarbonylmethylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

Intermediate 5 (0.220g) was dissolved in a mixture of isopropanol (10ml) and water (10ml); then 5% palladium on activated carbon (0.022g) and sodium hydrogen carbonate (0.035g) were added. The mixture was hydrogenated (1

atm.) for 3 hrs, filtered on a celite pad and extracted with diethyl ether. The aqueous layer was freeze dried to give the title compound (0.175g) as a white solid.

5 IR (CDCl<sub>3</sub>) V<sub>max</sub> cm<sup>-1</sup>: 1749, 1653.

<sup>1</sup>H-NMR (300MHz, D<sub>2</sub>O): 7.27 (t), 7.19 (t), 7.13 (d), 4.76 (m), 4.34 (m), 4.06 (m), 3.93 (dd), 3.19 (dd), 2.80 (m), 2.73 (s), 2.59 (s), 2.11 (dm), 1.65 (m), 1.50-1.20 (m), 1.09 (d).

10 Example 5

Sodium-(4S,8S,9R,10S,12R)-4-[N-[N-(2-pyridyl)-N-methylaminocarbonyl]-N-methylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

15 Intermediate 7 (0.110g) was dissolved in a mixture of isopropanol (10ml) and water (10ml); then 5% palladium on activated carbon (0.011g) and sodium hydrogen carbonate (0.018g) were added. The mixture was hydrogenated (1 atm.) for 3 hrs, filtered on a celite pad and extracted with diethyl ether. The aqueous layer was freeze dried to give the title compound (0.070g) as a white solid.

20 IR (CDCl<sub>3</sub>) V<sub>max</sub> cm<sup>-1</sup>: 1751, 1653, 1591.

<sup>1</sup>H-NMR (300MHz, D<sub>2</sub>O): 8.1 (dd), 7.63 (td), 6.96 (t), 6.86 (d), 4.98 (bm), 4.04 (m), 3.89 (dd), 3.20 (dd), 3.06 (m), 2.88 (m), 2.66 (s), 2.08 (m), 1.72 (m), 1.60-1.20 (m), 1.08 (d).

25 Example 6

Sodium-(4S,8S,9R,10S,12R)-4-[2-(2-pyridylethyl)methylaminocarbonylmethylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

30 Intermediate 9(0.120g) was dissolved in a mixture of isopropanol (10ml) and water (10ml); then 5% palladium on activated carbon (0.012g) and sodium hydrogen carbonate (0.019g) were added. The mixture was hydrogenated (1 atm.) for 3 hrs, filtered on a celite pad and extracted with diethyl ether. The aqueous layer was freeze dried to give the title compound (0.080g) as a white solid.

35

<sup>1</sup>H-NMR (300MHz, D<sub>2</sub>O): 8.27 n(d), 7.62 (m), 7.20 (d), 7.13 (m), 4.7 (m), 4.03 (m), 3.79 (dd), 3.52 (m), 3.14 (dd), 2.88 (m), 2.74 (s), 2.29 (s), 2.40 (m), 1.90 (m), 1.60 (m), 1.40-1.10 (m), 1.10 (d).

5 MS (VGquattro-FAB-NBA) m/z: 465.

#### Example 7

Disodium (4S,8S,9R,10S,12R) 4-[N-[(1"-S-1-carboxyethyl)carbamoyl]-(N-methyl))amino-10-[1'-hydroxyethyl]-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]undec-2-ene-2-carboxylate

10 A suspension of intermediate 6 (130mg), sodium hydrogen carbonate (30mg), 10% palladium on carbon (13mg) in isopropanol (15ml) and water (15ml) was hydrogenated at 1atm for 1h. After filtration, the solution was concentrated *in vacuo* to half volume and freeze dried. The residue was purified by preparative  
15 HPLC (technoprep 40-63 C18; elution acetonitrile/water 10:90) to give the title compound (8mg) as a white solid.

IR (nujol)  $\nu_{\max}$  cm<sup>-1</sup>: 3389 (OH and NH); 1770 and 1610 (C=O)

<sup>1</sup>H-NMR (500MHz, D<sub>2</sub>O): 5.26 (dd); 4.15 (m); 4.06 (dd); 3.97 (q); 3.27 (dd); 3.07 (m); 2.94 (s); 2.10 (m); 1.86 (m); 1.76-1.54 (m); 1.27 (m); 1.23 (d); 1.20 (d).

20 MS (VGquattro-FAB-NBA) m/z: 440

#### Example 8

Sodium-(4S,8S,9R,10S,12R)-4-[[[(phenyl-N'-methyl)-amino]carbonyl-N-methylamino]-10-(1'hydroxyethyl-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-carboxylate

25 To a solution of intermediate 18 ( 0.10 g ) in dry THF ( 4 ml ) at 20°C tetrakis (triphenylphosphine) palladium(0) ( 10 mg ) and triethylphosphine ( 3 mg ) were added at 20°C. After 10 min. sodium ethyl oxanoate ( 0.5 M solution in THF ) ( 0.41 ml ) was added and the resulting mixture was left under stirring for 30  
30 min. A 1/1 diethyl ether/petroleum ( 10 ml ) solution was then added , the solid was filtered , washed twice with the same mixture to give the title compound (42 mg ).

<sup>1</sup>H-NMR ( 300MHz, D<sub>2</sub>O ) : 7.27(m), 7.08 (m), 7.04 (m), 4.98 (m), 4.05 (m), 3.94(dd), 3.21 (dd), 3.04 (s), 2.83 (m), 2.45 (s), 2.03 (m), 1.70 (m), 1.56-1.24  
35 (m), 1.14 (m), 1.09 9d).

Example 9

Sodium-(4S,8S,9R,10S,12R)-4-(3"-pyridineaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

- 5 (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid(130mg) was suspended in acetonitrile(15ml) at room temperature under a nitrogen atmosphere. Triethylamine(75mg) was added to the reaction mixture which was then stirred at room temperature for 10 mins. Then 3-  
10 pyridine-isocyanate(0.4g) was added and the mixture stirred for a further 20 mins. Next a 0.5M solution of sodium-2 -ethylhexanoate(1.0ml) was added to the stirred reaction mixture. Stirring was continued for a further 10 mins., after which the volume of solvent was reduced by half *in vacuo*. Acetone(10ml) and light petroleum(10ml) were then added to the reaction mixture. This resulted in  
15 the precipitation of an off-white solid, which was filtered, washed with ethyl acetate(2x30ml), diethyl ether(2x30ml), and dried to afford the title compound (107mg) as a white solid.

IR(nujol) Vmax cm<sup>-1</sup>: 3340-3194(N-H), 1755(C=O, b-lactam), 1680(C=C, C=N).

<sup>1</sup>H-NMR (300MHz, D<sub>2</sub>O):8.30(bs), 8.05(d), 7.63(d), 7.22(dd), 5.16(bs), 4.04(m), 3.85(dd), 3.22(dd), 3.01(m), 1.83(m), 1.8-1.7(m), 1.65-1.50(m), 1.3-1.2(m), and 1.09(d).

Example 10

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-hydroxyphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

- To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (200mg) in acetone  
30 (30ml) , triethylamine (0.15 ml) was added under nitrogen at 22°. The solution was stirred for 10 min , then o-allyloxycarbonyloxyphenyl isocyanate (245 mg) was added. The obtained solution was stirred for 15 min, then a solution of dimedone (159 mg) and tetrakis(triphenylphosphine)-palladium (0) (26 mg) in acetone (3 ml) was added. The resulting solution was stirred for 90 min, then a  
35 0.5 M solution of sodium- 2- ethylhexanoate in tetrahydrofuran (1.5 ml) was

added . After 10 min the mixture was partially concentrated and stirred for 1 h, the solid was centrifuged, washed with ethyl acetate and ether and dried to afford a white solid (180 mg). The solid was purified by preparative HPLC (column techoprep 40-63 C18). The title compound (36 mg) was obtained by  
5 freeze drying the fraction eluted with a 10 % of acetonitrile in water.

IR (nujol) Vmax cm-1: 1599 (C=O), 1761 ( C=O  $\beta$ -lactam), 3341 (O-H, N-H);

1H-NMR ( 300 MHz, D2O): 7.19(m), 6.96(m), 6.79(m), 5.18(m), 4.07(m),  
10 3.99(dd), 3.23(dd), 3.04(m), 2.10(m) , 1.12(d) p.p.m.

#### Example 11

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-  
methylsulphonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-  
15 azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone (15ml) , triethylamine (0.08 ml) was added under nitrogen at 22°C . The solution was stirred for 10 min , then p-methylsulphonylphenyl isocyanate (111  
20 mg) was added. The obtained solution was stirred for 15 min, then a 0.5 M solution of sodium- 2- ethylexanoate in tetrahydrofuran (0.75 ml) was added . After 10 min the mixture was partially concentrated and treated with petroleum ether to give a solid which was centrifuged, washed with petroleum ether/acetone 2/1 and dried to afford title compound (109 mg) as a pale yellow  
25 solid.

IR (nujol) Vmax cm-1: 1693 (C=O), 1755 ( C=O  $\beta$ -lactam), 3331 (O-H, N-H);

1H-NMR ( 300 MHz, D<sub>2</sub>O): 7.69(d), 7.43(d), 5.19(m), 4.05(m), 3.95(dd),  
30 3.22(dd), 3.07(s), 3.03(m), 1.88-1.70(m) , 1.30-1.00(m), 1.09(d) p.p.m.

#### Example 12

Sodium (4S, 8S, 9R, 10S, 12R)-4-(uracil-5'-amino)carbonylamino-10-(1'  
-hydroxyethyl)-11-oxo-1-aza-tricyclo [7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylate

To a suspension of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetonitrile (15 ml), triethylamine (0.10 ml) was added under nitrogen at 22°C. The suspension was stirred for 5 min and then uracyl-5-isocyanate (75 mg) was added and reaction stirred at 70 °C for 1 hour, then more isocyanate (20 mg) was added and reaction stirred at 70 °C for further 40'. The resulting suspension was cooled, solvent evaporated and residue resuspended in acetone (15 ml). Sodium 2-ethylhexanoate (0.75 ml of a 0.5M solution in THF) was added, suspension stirred for for 30' under N<sub>2</sub> and then filtered, washing with ethyl acetate and diethyl ether, to give 400 mg of a solid which was purified by preparative HPLC (column techoprep 40-63 C18) to afford the title compound as a white solid (31 mg)

IR (nujol) Vmax cm<sup>-1</sup>: 1666 (C=O), 1713 ( C=Oβ-lactam), 3335-3202 (O-H, N-H);

<sup>1</sup>H-NMR ( 300 MHz, D<sub>2</sub>O, ppm): 7.47(bs), 5.10(bs), 4.06(m), 3.99(dd), 3.22(dd), 3.00(s), 1.80-1.70(m), 1.30-1.10(m), 1.10(d)

### Example 13

Sodium-(4S,8S,9R,10S,12R)-4-(3''-picolylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid(120mg) was suspended in acetone(20ml) at room temperature under a nitrogen atmosphere. Triethylamine(0.2ml) was added to the reaction mixture which was then stirred at room temperature for 10 mins. Then 3-picoly-aminocarbonylimidazole (0.45g) was added and the mixture stirred at 50°C for 1 hr. The solution was cooled at 0°C and a 0.5M solution of sodium-2 -ethylhexanoate(0.8ml) was added to the stirred reaction mixture. Stirring was continued for a further 10 mins., after which the volume of solvent was reduced by half *in vacuo*. This resulted in the precipitation of an off-white solid, which was filtered,washed with ethyl acetate(2x30ml), diethyl ether(2x30ml),and dried to afford the title compound (120mg) as a white solid.

IR(nujol)  $V_{\max}$   $\text{cm}^{-1}$ : 3265(N-H), 1751(C=O,  $\beta$ -lactam).

$^1\text{H-NMR}$  (300MHz,  $\text{D}_2\text{O}$ ): 8.2(m), 7.51(d), 7.25(m), 4.96(bm), 4.34(d), 4.1-4.0(m), 3.84(dd), 3.16(dd), 2.90(m), 1.8-1.7(m), 1.6-1.4(m), 1.25(m), and 1.09(d).

5

#### Example 14

Sodium-(4S,8S,9R,10S,12R)-4-(2"-furfurylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

10 (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (130mg) was suspended in acetone (20ml) at room temperature under a nitrogen atmosphere. Triethylamine (0.2ml) was added to the reaction mixture which was then stirred at room temperature for 10 mins. Then 2-furfurylaminocarbonylimidazole (0.45g) was added and the mixture stirred at 50°C for 1hr. The solution was cooled at 15 0°C and a 0.5M solution of sodium-2-ethylhexanoate (0.8ml) was added to the stirred reaction mixture. Stirring was continued for a further 10 mins., after which the volume of solvent was reduced by half *in vacuo*. This resulted in the precipitation of an off-white solid, which was filtered, washed with ethyl acetate (2x30ml), diethyl ether (2x30ml), and dried to afford the title compound 20 (60mg) as a white solid.

IR(nujol)  $V_{\max}$   $\text{cm}^{-1}$ : 3302(N-H), 1753(C=O,  $\beta$ -lactam).

25  $^1\text{H-NMR}$  (300MHz,  $\text{D}_2\text{O}$ ): 7.25(m), 6.21(dd), 6.02(d), 4.95(m), 4.22(d), 4.04(m), 3.98(d), 3.85(dd), 3.16(dd), 2.89(m), 1.8-1.64(m), 1.6-1.38(m), 1.3-1.0(m), 1.09(d).

#### Example 15

30 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-methoxyphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone (15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C followed by o-methoxyphenyl isocyanate (0.078ml). The solution obtained was stirred for 35 60 min then a 0.5 M solution of sodium-2-ethylhexanoate in tetrahydrofuran

(0.67 ml) was added. After 10 min the mixture was partially concentrated and treated with petroleum ether (8ml) to give a precipitate which was filtered under N<sub>2</sub>, washed with petroleum ether/acetone 2/1 then petroleum ether, and dried to afford the title compound (102.6 mg) as a white solid.

5

IR (nujol) Vmax cm<sup>-1</sup>: 1753 (C=O β-lactam), 3339 (N-H);

1H-NMR (300 MHz, D<sub>2</sub>O): 7.30(d,1H), 7.00(t,1H), 6.92(d,1H), 6.34(t,1H), 5.18(s,1H), 4.07(m,1H), 3.99(dd,1H), 3.68(s,3H), 3.22(dd,1H), 3.02(s,1H), 1.90-1.70(m,2H), 1.70-1.50(m,2H), 1.30-1.10(m,2H), 1.12(d,3H) p.p.m.

10

#### Example 16

Sodium - (4S,8S,9R,10S,12R)-4-[(benzylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

15

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone (15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C. The solution was stirred for 10 min then benzyl isocyanate (0.070ml) was added. The solution obtained was stirred for 40 min then a 0.5 M solution of sodium-2-ethylhexanoate in tetrahydrofuran (0.74 ml) was added. After 15 min the mixture was partially concentrated and treated with petroleum ether to give a precipitate which was filtered under N<sub>2</sub>, washed with petroleum ether/acetone 2/1 then petroleum ether and dried to afford the title compound (67 mg) as a white solid.

20

25

IR (nujol) Vmax cm<sup>-1</sup>: 1757 (C=O β-lactam), 3320 (N-H);

1H-NMR (300 MHz, D<sub>2</sub>O): 7.30-7.10(m,5H), 4.99(s,1H), 4.28(d,1H), 4.10-4.00(m,2H), 3.85(dd,1H), 3.17(dd,1H), 2.89(m,1H), 1.84-1.64(m,2H), 1.60-1.40(m,2H), 1.30-1.10(m,2H), 1.11(d,3H) p.p.m.

30

#### Example 17

Sodium - (4S,8S,9R,10S,12R)-4-[(3''-cyanophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.



To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone (15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C followed by m-cyanophenyl isocyanate (82mg). The solution obtained was stirred for 90 min then a further portion of m-cyanophenyl isocyanate was added (27mg). The mixture was stirred for 30 min and then filtered giving a solution to which was added a 0.5 M solution of sodium- 2- ethylhexanoate in tetrahydrofuran (0.67 ml). After 5 min the mixture was partially concentrated and treated with petroleum ether (7ml) to give a precipitate which was filtered under N<sub>2</sub>, washed with petroleum ether/acetone 2/1 then petroleum ether, and dried to afford the title compound (73.5 mg) as a white solid.

IR (nujol) Vmax cm<sup>-1</sup>: 1680(C=O), 1753 (C=O β-lactam), 2250(CN), 3300 (O-H,N-H);

<sup>1</sup>H-NMR ( 300 MHz, D<sub>2</sub>O): 7.60(s,1H), 7.41(m,1H), 7.32(m,2H), 5.18(m,1H), 4.07(m,1H), 3.97(dd,1H), 3.24(dd,1H), 3.02(m,1H), 1.85(m,1H), 1.76(m,1H), 1.70-1.48(m,3H), 1.30-1.10(m,1H), 1.12(d,3H) p.p.m.

#### Example 18

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-phenoxyethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone (15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C then phenoxyethyl isocyanate (0.200ml) was added. The solution obtained was stirred for 2.5h then a 0.5 M solution of sodium- 2- ethylhexanoate in tetrahydrofuran (0.700 ml) was added. After 10 min the mixture was filtered under N<sub>2</sub>, washed with ethyl acetate (2x50ml) and diethyl ether (2x50ml), then dried to afford the title compound (119.3 mg) as a white solid.

IR (nujol) Vmax cm<sup>-1</sup>: 1653(C=O), 1751 (C=Oβ-lactam), 3310 (N-H);

<sup>1</sup>H-NMR ( 400 MHz, D<sub>2</sub>O): 7.19(td,2H), 6.87(t,1H), 6.81(dd,2H), 4.90(bm,1H), 3.92(m,1H), 3.88(m,2H), 3.83(m,1H), 3.50(ddd,1H), 3.17(ddd,1H), 3.04(dd,1H),

2.77(m,1H), 1.74(m,1H), 1.63(m,1H), 1.48(m,3H), 1.13(m,1H), 1.05(d,3H)  
p.p.m.

#### Example 19

5 Sodium - (4S,8S,9R,10S,12R)-4-[(4"-acetamidophenylaminocarbonyl)amino]-  
10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-  
carboxylate.

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-  
10 azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone  
(15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C followed  
by p-acetamidophenyl isocyanate (100mg). The solution obtained was stirred  
for 30 min then H<sub>2</sub>O mQ (3ml) was added. After 60 min a 0.5 M solution of  
sodium- 2- ethylhexanoate in tetrahydrofuran (0.670 ml) was added stirring was  
continued for 10 min then the mixture was partially concentrated and  
15 azeotroped several times with acetonitrile. The resulting solid was suspended in  
acetone, filtered and washed with  
ethyl acetate (2x50ml), diethyl ether (2x50ml) and dried to afford the title  
compound (123.5 mg) as a white solid.

20 IR (nujol) Vmax cm-1: 1661(C=O), 1755 (C=O β-lactam), 3304 (O-H,N-H);

1H-NMR ( 400 MHz, D<sub>2</sub>O): 7.19(d,2H), 7.13(d,2H), 5.15(m,1H), 4.06(m,1H),  
3.96(dd,1H), 3.23(dd,1H), 3.02(m,1H), 1.99(s,3H), 1.90-1.70(m,2H), 1.70-  
1.45(m,3H), 1.32-1.00(m,1H), 1.11(d,3H) p.p.m.

25

#### Example 20

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-cyanophenylaminocarbonyl)amino]-10-(1'-  
hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

To a solution of (4S,8S,9R,10S,12R)-4-amino-10-(1'-hydroxyethyl)-11-oxo-1-  
30 azatricyclo[7,2,0,0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid (100mg) in acetone  
(15ml), triethylamine (0.100 ml) was added under nitrogen at 22°C followed  
by p-cyanophenyl isocyanate (0.081mg). The solution obtained was stirred for  
60 min then a 0.5 M solution of sodium- 2- ethylhexanoate in tetrahydrofuran  
(0.74 ml) was added. After 10 min the mixture was partially concentrated and  
35 treated with petroleum ether (8ml) to give a precipitate which was filtered under

N<sub>2</sub>, washed with petroleum ether/acetone 2/1 then petroleum ether, and dried to afford the title compound (102.6 mg) as a white solid.

5 IR (nujol) Vmax cm<sup>-1</sup>: 1695(C=O), 1749 (C=O β-lactam), 2280(CN), 3352 (O-H,N-H);

1H-NMR ( 300 MHz, D<sub>2</sub>O): 7.52(m,2H), 7.31(m,2H), 5.18(m,1H), 4.05(m,1H), 3.94(dd,1H), 3.22(dd,1H), 3.00(m,1H), 1.86-1.70(m,2H) , 1.70-1.46(m,3H), 1.30-1.00(m,1H), 1.09(d,3H) p.p.m.

10

#### Example 21

Sodium-(4S,8S,9R,10S,12R)-4-(aminocarbonyl-N-methylamino)-10-(1'hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

15 To a solution of (4S,8S,9R,10S,12R)-4-N-methylamino-10-(1'hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-carboxylic acid ( 116 mg ) in a mixture of water ( 5.5 ml) and acetone ( 3 ml ) at 20 °C a solution of sodium hydrogen carbonate ( 36 mg ) in water ( 0.5 ml ) was added ; after 10 min. trimethylsilyl isocyanate ( 0.28 ml ) was added .

20 Further amounts of trimethylsilyl isocyanate were required ( 4 x 0.28 ml ) to obtain complete reaction . The reaction mixture was concentrated under *vacuo* and the crude compound passed through a reverse phase column ( techoprep 40-63 C18 ).

The title compound (30 mg ) was obtained by freeze drying the fraction eluted with a 10% solution of acetonitrile in water.

25 <sup>1</sup>H-NMR ( 300MHz, D<sub>2</sub>O ): 5.14(bm), 4.06 (m), 3.97(dd), 3.20 (dd), 3.00 (m), 2.85 (s), 1.98 (m), 1.80 (m), 1.70-1.60 (m), 1.10 (d). MS (VGquattro-FAB(+))NBA m/z: 346

30 The following examples No's 22-91 were prepared from Intermediates 19 or 20 by reaction with the appropriate isocyanate R<sub>2</sub>NCO or amine R<sub>2</sub>NH<sub>2</sub>

Details of the reaction conditions used are also included in the table given below.

35

22Sodium-(4S,8S,9R,10S,12R)-4-(4"-trifluoromethylphenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate235 Sodium - (4S,8S,9R,10S,12R)-4-[(4"-methylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.24Sodium - (4S,8S,9R,10S,12R)-4-[(4"-nitrophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.10 25Sodium-(4S,8S,9R,10S,12R)-4-(4"-chlorophenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate2615 Sodium - (4S,8S,9R,10S,12R)-4-[(3"-nitrophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.27Sodium - (4S,8S,9R,10S,12R)-4-[(4"-dimethylaminosulfonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.20 28Sodium-(4S,8S,9R,10S,12R)-4-(2"-dimethylaminocarbonylphenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate2925 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-chlorophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.3030 Sodium - (4S,8S,9R,10S,12R)-4-[(3"-trifluoromethylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.31Sodium-(4S,8S,9R,10S,12R)-4-[(2"-trifluoromethylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate32

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-trifluoromethylpyrid-3"-yl)-aminocarbonyl]amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

33

- 5 Sodium - (4S,8S,9R,10S,12R)-4-[(3"-dimethylaminosulfonylphenylaminocarbonyl) amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

34

- 10 Sodium (4S, 8S, 9R, 10S, 12R)-4-(1",3"-dimethyluracil-5"-amino)carbonylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo [7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylate

35

- 15 Sodium-(4S,8S,9R,10S,12R)-4-(2"-methylsulfonyloxyphenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

36

Sodium-(4S,8S,9R,10S,12R)-4-(5"-N-methyl-2"-pyridon-aminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

37

- 20 Sodium - (4S,8S,9R,10S,12R)-4-[(cyclohexylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

38

Sodium - (4S,8S,9R,10S,12R)-4-[(3"-furylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

39

- 25 Sodium - (4S,8S,9R,10S,12R)-4-[(cyclopropylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

40

- 30 Sodium - (4S,8S,9R,10S,12R)-4-[(3-(N-methylpyridinium)methylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

41

Sodium - (4S,8S,9R,10S,12R)-4-[(1"methyl-1H-pyrrol-2"-yl)-aminocarbonyl]amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

35

42

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-chlorobenzylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

43

5 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-phenylethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

44

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-furylaminocarbonyl) amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

45

10 Sodium (4S, 8S, 9R, 10S, 12R)-4-(3"-thiophen-aminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo [7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylate.

46

Sodium-(4S,8S,9R,10S,12R)-4-(2"-thiophen-aminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

15

47

Sodium-(4S,8S,9R,10S,12R)-4-(2"-methyl-thiophen-5"-yl-aminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

48

20 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-phenyl-pyridin-5"-yl-aminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

49

25 Sodium - (4S,8S,9R,10S,12R)-4-[(3"-bromopyridin-5"-yl-aminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

50

Sodium - (4S,8S,9R,10S,12R)-4-[(2",3"-dichloro-pyridin-5"-yl-aminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

30

51

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-chloro-pyridin-5"-yl-aminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

52

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-methyl-1",2",3"-thiadiazol-5"-yl)-aminocarbonyl]amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

53

5 Sodium - (4S,8S,9R,10S,12R)-4-[(1",2",3"-thiadiazol-4"-yl)-aminocarbonyl]amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

54

10 Sodium-(4S,8S,9R,10S,12R)-4-[(2"-phenylethylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

55

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-chlorobenzylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

15 56

Sodium - (4S,8S,9R,10S,12R)-4-[(phenoxyethylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

57

20 Sodium-(4S,8S,9R,10S,12R)-4-[(3"-picolylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

58

25 Sodium - (4S,8S,9R,10S,12R)-4-[(ethoxycarbonylmethylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

59

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-hydroxyethylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

30 60

Sodium-(4S,8S,9R,10S,12R)-4-(2"-chloroethylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

61

35 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-hydroxyethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

62

Sodium - (4S,8S,9R,10S,12R)-4-[(5'-ethoxycarbonylpentylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

5

63

Sodium-(4S,8S,9R,10S,12R)-4-[(2'-trimethylammoniummethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

64

10

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-azidoethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

65

15

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-N-formylpiperidinaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

66

Sodium (4S, 8S, 9R, 10S, 12R)-4-[(tetrahydropyran-4"-ylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylate

20

67

Sodium-(4S,8S,9R,10S,12R)-4-[4"-((N-allyloxycarbonyl)piperidinaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

68

25

Sodium-(4S,8S,9R,10S,12R)-4-[(cyclohexylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

69

Sodium - (4S,8S,9R,10S,12R)-4-[(benzylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

30

70

Sodium - (4S,8S,9R,10S,12R)-4-[(ethylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

71

35

Sodium - (4S,8S,9R,10S,12R)-4-[(tert-butylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.



72

Sodium - (4S,8S,9R,10S,12R)-4-[(cyclopropylaminocarbonyl)methylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

73

5 Sodium - (4S,8S,9R,10S,12R)-4-[(4'-aminosulfonylbenzylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

74

10 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-methoxycarbonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

75

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-isopropylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

15

76

Sodium - (4S,8S,9R,10S,12R)-4-(4"-bromophenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

77

20 Sodium (4S, 8S, 9R, 10S, 12R)-4-(3"-chloro-4"-fluorophenylaminocarbonylamino)-10-(1-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene carboxylate

78

Sodium-(4S,8S,9R,10S,12R)-4-(4"-methoxyphenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

25

79

Sodium-(4S,8S,9R,10S,12R)-4-(3",4",5"-trimethoxyphenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

80

30 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-nitrophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

81

Sodium - (4S,8S,9R,10S,12R)-4-[(3"-methylthiophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

35

82

Sodium - (4S,8S,9R,10S,12R)-4-[(2"-methylsulfonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

83

5 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-methylsulfinylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

84

10 Sodium - (4S,8S,9R,10S,12R)-4-[4"-(N-succimidyl)phenylaminocarbonylamino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

85

15 Sodium - (4S,8S,9R,10S,12R)-4-[(2"-chloropyrid-3"-yl-aminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

86

Sodium-(4S,8S,9R,10S,12R)-4-[(3",4"-dimethyl-1",2"oxazolyl-5-methylaminocarbonyl) amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

20 87

Sodium-(4S,8S,9R,10S,12R)-4-(aminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate

88

25 Sodium - (4S,8S,9R,10S,12R)-4-[(dimethylaminoethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

89

Sodium - (4S,8S,9R,10S,12R)-4-[(4"-fluoro-3"-chlorobenzylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

30 90

Sodium - (4S,8S,9R,10S,12R)-4-[(propargylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

91

35 Sodium - (4S,8S,9R,10S,12R)-4-[(allylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylate.

Example	Starting Material Int. No	Material WT (g)	solvent volume ml	isocyanate R <sub>2</sub> NCO R <sub>2</sub>	time	yield (mg)	IR cm <sup>-1</sup>	H-NMR
22	19	0.250	acetone 30ml	4-trifluoromethyl phenyl	2 hrs	62	1749	7.32 (d) 3.97 (dd) 3.24 (dd)
23	19	0.150	acetone 18ml	4-methylphenyl	1 hr	45	1757	7.04 (m) 3.98 (dd) 3.23 (dd)
24	19	0.100	acetone 15ml	4-nitrophenyl	30 min	30	1751	8.04 (d) 3.97 (dd) 3.24 (dd)
25	19	0.100	acetone 15ml	4-chlorophenyl	40 min	25	1751	7.20 (d) 3.97 (dd) 3.23 (dd)
26	19	0.100	acetone 15ml	3-nitrophenyl	20 min	30	1768	7.78 (d) 3.97 (dd) 3.24 (dd)

27	19	0.100	CH <sub>3</sub> CN 12ml	4-dimethylamino sulphonylphenyl	40 min	85	1755	7.58 (d) 3.96 (dd) 3.22 (dd)
28	19	0.100	CH <sub>3</sub> CN 12ml	2-dimethylamino carbonylphenyl	45 min	51	1749	7.33 (m) 3.99 (dd) 3.22 (dd)
29	19	0.100	acetone 15ml	2-chlorophenyl	30 min	72	1755	7.17 (td) 4.00 (dd) 3.23 (dd)
30	19	0.100	acetone 15ml	3-trifluoromethyl phenyl	1 hr	22	1753	7.53 (s) 3.97 (dd) 3.21 (dd)
31	19	0.100	acetone 15ml	2-trifluoromethyl phenyl	1 hr	47	1752	7.58 (m) 3.99 (dd) 3.21 (dd)
32	19	0.100	CH <sub>3</sub> CN 12ml	4-trifluoromethyl pyrid-3-yl	30 min	50	1755	7.61 (d) 4.01 (dd) 3.23 (dd)

33	19	0.100	CH <sub>3</sub> CN 12ml	3-dimethylamino sulphonylphenyl	45 min	30	1755	7.67 (s) 3.95 (dd) 3.21 (dd)
34	19	0.100	CH <sub>3</sub> CN 14ml	1.3-dimethyl uracil-5-yl	2 hrs	70	1751	7.59 (s) 3.99 (dd) 3.22 (dd)
35	19	0.100	CH <sub>3</sub> CN 12ml	2- methylsulphonyl- oxy phenyl	25 min	70	1749	3.20 (s) 4.02 (dd) 3.25 (dd)
36	19	0.100	CH <sub>3</sub> CN 15ml	N-methyl-2-oxo pyrid-5-yl	4 hrs	39	1751	6.45 (d) 3.97 (dd) 3.23 (dd)
37	19	0.1	acetone 15ml	cyclohexyl	6 h	35	1751	3.21(dd), 3.95(dd), 3.24(m)

38	19	0.11	acetone 15ml	3-furyl	15'	79	1749	3.21(dd), 3.94(dd), 7.45(d)
39	19	0.1	acetone 4ml H2O 2ml	cyclopropyl	1 h	18	1749	3.2(dd), 3.93(dd), 2.29(m)
40 (a)	19	0.14	MeCN 15ml	3-(N-methylpyridinium) methyl	15'	87	1755	3.23(dd), 3.95(dd), 8.49(d)
41	19	0.1	acetone 10ml	1-methyl-1H-pyrrol-2-yl	1h 15'	33	1757	3.2-3.3(dd), 4.00(dd), 3.24(s)
42	19	0.13	acetone 10ml	4-chlorobenzyl	1h 30'	61	1755	3.14(dd), 3.78(dd), 4.24(d)

43	19	0.1	acetone 10ml	2-phenylethyl	2h	32	1755	3.11(dd), 3.77(dd), 7.17(m)
44	19	0.13	MeCN 15ml	2-furyl	30'	57	1751	3.23(dd), 3.99(dd), 7.12(m)
45	19	0.13	MeCN 15ml	3-thiophenyl	30'	44	1749	3.19(dd), 3.93(dd), 7.18(dd)
46	19	0.13	MeCN 15ml	2-thiophenyl	1h	50	1751	3.20(dd), 3.93(dd), 6.47(m)
47	19	0.13	MeCN 15ml	2-methyl- thiophen-5-yl	45'	71	1751	3.16(dd), 3.82(dd), 6.7(m)

48	19	0.065	MeCN 10ml	2-phenyl-pyridin-5-yl	50'	47	1751	3.23(dd), 3.97(dd), 8.37(d)
49	19	0.1	MeCN 10ml	3-Bromo-pyridin-5-yl	30'	61	1751	3.23(dd), 3.96(dd), 8.26(d)
50	19	0.1	MeCN 10ml	2,3-Dichloro-pyridin-5-yl	30'	54	1751	3.26(dd), 3.99(dd), 8.12(d)
51	19	0.1	MeCN 15ml	2-Chloro-pyridin5-yl	30'	58	1755	3.27(dd), 3.99(dd), 7.69(dd)
52	19	0.1	MeCN 15ml	4-methyl-1,2,3-thiadiazol-5-yl	40'	42	1751	3.22(dd), 3.95(dd), 2.39(s)



53	19	0.11	MeCN 15ml	1,2,3-thiadiazol-4-yl	1h	60	1751	3.22(dd), 3.97(dd), 8.44(s)
54	20	0.09	water : acetone (1:1) 6 ml	2-phenylethyl	30'	55	1747	3.07(dd), 3.42(m), 7.0- 7.25(m)
55	20	0.1	water : acetone (1:1) 8 ml	4-chlorobenzyl	30'	75	1747	3.07(m), 7.02(d), 7.12(d)
56	20	0.1	water : acetone (1:1) 6 ml	2-phenoxyethyl	30'	60	1745	3.04(dd), 6.92(m), 7.23(m)
57 (a)	20	0.1	acetone 5 ml	3-picoyl	2 h	64	1745	3.10(d), 7.48(d), 8.2(m)

58	20	0.1	water : acetone (1:1) 6 ml	ethoxycarbonyl- methyl	30'	78	1781	1.09(t), 3.18(dd), 3.64- 3.75(AB)
59	20	0.1	water : acetone (1:1) 6 ml	2-trimethylsilyl oxyethyl	1 h	60	1745	3.08(m), 3.17(dd), 3.89(t)
60	19	0.12	acetone 15 ml	2-chloroethyl	1 h	66	1755	3.15(m), 3.19(dd), 3.40(m)
61	19	0.1	water : acetone (1:1) 8 ml	2-trimethylsilyl oxyethyl	1 h	70	1744	3.10(dd), 3.23(dd), 3.44(m)
62	19	0.1	water : acetone (1:1) 8 ml	5-ethoxycarbonyl pentyl	1 h	90	1734	2.19(t), 2.8- 2.9(m), 3.14(dd)

63 (a)	19	0.12	MeCN 10 ml	trimethyl- ammonium- ethyl	30'	72	1745	3.05(m), 3.06(s), 3.44-3.66(m)
64	19	0.2	water: acetone (1:1) 12 ml	2-azidoethyl	1 h	160	1745	3.15(m), 3.21(m), 3.36(m)
65	20	0.09	water: acetone (1:1) 4 ml	4-N- formylpiperidinyl	1h	63	1749	5.1 (m), 3.88 (dd), 3.15 (m)
66	20	0.1	water: acetone (1:1) 5 ml	tetrahydropyran- 4-yl	1.5h	90	1749	3.88 (dd), 3.1 (dd), 2.87 (s)
67	20	0.1	water: acetone (1:1) 6 ml	N- allyloxycarbonyl piperidin-4-yl	6h	80	1747	3.88 (dd), 3.13 (dd), 2.88 (s)

68	20	0.125	THF/H <sub>2</sub> O (9:1) 4ml	cyclohexyl	30'	45	1750	3.89(dd), 3.15(dd), 1.2- 0.8(m)
69	20	0.125	THF/H <sub>2</sub> O (1:1) 4ml	benzyl	45'	110	1740	3.71(dd), 3.11(dd), 7.24- 7.07(m)
70	20	0.125	THF/H <sub>2</sub> O (1:1) 4ml	ethyl	30'	15	1749	3.92(dd), 3.18(dd), 0.86(l)
71	20	0.1	Acetone/ H <sub>2</sub> O (1:1) 4ml	t-butyl	30'	12	1753	3.91(dd), 3.17(dd), 1.08(s)
72	20	0.1	toluene/ H <sub>2</sub> O (1:1) 4ml	cyclopropyl	1h	17	1749	3.88(dd), 3.16(dd), 0.48(m)

73	19	0.1	acetone 40	4-aminosulphonyl benzyl	3	42	1752	4.39(d) 3.83(dd) 3.16(dd)
74	19	0.1	acetone 30	2- methoxycarbonyl phenyl	1	33	1759	3.74(s) 3.24(dd) 1.12(d)
75	19	0.1	acetone 15	2-isopropyl- phenyl	1	65	1755	3.99(dd) 3.22(dd) 1.11(d)
76	19	0.1	acetone 12	4-bromophenyl	1	79	1751	3.97(dd) 3.23(dd) 1.12(d)
77	19	0.105	acetone 15	3-chloro-4-fluoro- phenyl	1.5	52	1755	3.97(m) 3.23(m) 1.11(d)

78	19	0.069	THF	6	4-methoxyphenyl	3	10	1750	3.98(dd) 3.24(dd) 1.12(d)
79	19	0.06	acetone	7	3,4,5-trimethoxy phenyl	n.d.	27	1752	3.68(s) 3.59(s) 3.23(dd)
80	19	0.1	acetone	15	2-nitrophenyl	3	28	1718	3.99(dd) 3.22(dd) 1.10(d)
81	19	0.1	acetone	15	3-methylthio phenyl	1	75	1755	3.21(dd) 2.31(s,3H) 1.09(d)
82	19	0.1	CH <sub>3</sub> CN	15	2- methylsulphonyl phenyl	0.75	66	1747	3.99(dd) 3.24(dd) 3.04(s)

83	19	0.1	CH <sub>3</sub> CN	25.6	2-methylsulphonyl phenyl	4	17	n.d.	3.30(dd) 2.73(s) 1.16(d)
84	19	0.1	CH <sub>3</sub> CN	25	4-N-succinimido phenyl	1.5	87	1755	3.95(dd) 3.21(dd) 2.77(m)
85	19	0.1	CH <sub>3</sub> CN	25.6	2-chloro-pyrid-3- yl-5-methyl	0.75	90	1751	3.99(dd) 3.23(dd) 1.10(d,3H)
86	19	0.1	acetone	30	3,4-dimethyl 1,2- oxazoly-5- methyl	1.5	7	n.d.	3.16(dd) 2.17(s) 2.00(s)
87	19	0.2	acetone	30	trimethylsilyl	n.d.	20	n.d.	3.95(dd) 3.20(dd) 1.10(d)

88	19	0.1	acetone 20	dimethylamino-ethyl	7	15	1751	3.94(dd) 3.23(dd) 2.71(s)
(a) 89	19	0.11	acetone 20ml	4-fluoro-3-chloro benzyl	1.5	88	1751	4.26(d), 3.86(dd), 3.15(dd)
(a) 90	19	0.15	acetone 20ml	propargyl	2	105	1753	3.95(dd), 3.20(dd), 2.37(t)
(a) 91	19	0.1	acetone 20ml	allyl	2	40	1750	5.96(d), 3.94(dd), 3.21(dd)

(a) In this process the amine  $R_2NH_2$  and carbonyldimidazole were used in place of isocyanate  $R_2NCO$ .



Pharmacy ExamplesTablets

5

mg/tab

	Compound of Example 1	320
	Lactose	150
10	Ethyl cellulose	20
	Sodium lauryl sulphate	7
	Magnesium stearate	3
	Tablet core	500mg

- 15 The active ingredient and the lactose are blended together and then granulated using water as the granulating fluid. The dried granules are blended with the ethyl cellulose, sodium lauryl sulphate and magnesium stearate and the tablet core formed using an appropriate punch. The tablet may then be coated using conventional techniques and coatings.

20

Example B

mg/tab

25	Compound of Example 1	320
	Compressible sugar	170
	Sodium lauryl sulphate	7
	Magnesium stearate	3
	Tablet core	500

30

- The active ingredient and the excipients are blended together and then compressed using an appropriate punch. If required the tablet thus formed may be coated in a conventional manner.

Granules

	mg/unit dose
5	
Compound of Example 1	320
Starch 100	
Cellulose	40
Polymethacrylate	30
10 Sodium lauryl sulphate	7
Magnesium stearate	3
Flavouring agent	qs

- 15 A solution of the active ingredient in ethanol is sprayed into a suitable fluid bed granulator charged with the major excipients. The granules so formed are dried and screened. If desired the granules may then be coated with a suitable enteric coating and dried. The dried granules are then blended with the remaining excipients including any flavouring agent and coated, for example with an enteric
- 20 coating. The granules thus obtained may be filled into capsules or the like for a single dose presentation or filled into bottles for subsequent preparation of a multi dose oral liquid presentation.

Dry Powder for Injection

- 25 active Ingredient (Compound of Example 1) 538mg per vial.

Fill sterile vials with the sterile active ingredient. Purge the vial head space with sterile nitrogen; close the vials using rubber plugs and metal overseals (applied by crimping). The product may be constituted by dissolving in Water for Injection

30 (10ml) or other suitable sterile vehicle for injection shortly before administration.

The antibacterial activity of the compounds of the invention may be readily determined using conventional test procedures. For example the antibacterial activity of the compounds of the invention was determined using a standard

35 microtiter broth serial dilution test. In this test the broth was incubated with

approximately  $10^5$  colony forming units of the test organism and incubated at  $35^\circ$  for 18 hours in the presence of test compound. Results obtained using the rest procedure are given in the table below and are expressed as minimum inhibitory concentrations (MIC) in micrograms/ml.

5

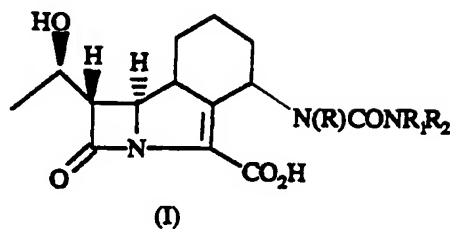
#### Example No's

Organism	1	10	12	13	9	21
S Aureus 663E	0.5	0.25	0.5	0.5	0.25	0.1
F Faecalis 85OE	2	1	2	2	1	8
E Coli TEMI	0.25	0.12	<0.1	0.25	0.12	0.1
E Cloacae	4	2	2	2	0.5	0.5
C Prefringens	<0.01	0.12	<0.1	0.12	0.12	0.1
B Fragilis	0.25	0.5	0.25	0.50	0.50	0.1

The compounds of the invention are essentially non toxic at therapeutically useful 10 doses. For example no adverse effects were observed when compounds of the invention were administered to mice at therapeutically useful dose levels.

## CLAIMS

(I) A compound of general formula (I)



salts and metabolically labile esters thereof;

wherein R represents hydrogen or C<sub>1-6</sub>alkyl;

R<sub>1</sub> represents hydrogen or C<sub>1-6</sub>alkyl;

R<sub>2</sub> represents hydrogen or an optionally substituted, alkyl, alkenyl, alkynyl, aryl, cycloalkyl or heterocyclic group.

(2) Compounds as claimed in Claim 1, wherein R represents hydrogen or methyl.

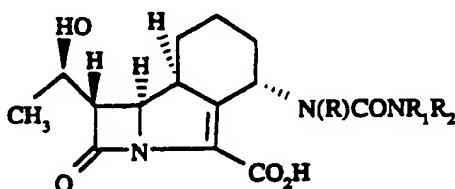
(3) Compounds as claimed in Claims 1 or 2 when R<sub>1</sub> represents hydrogen or methyl.

(4) Compounds as claimed in any of Claims 1 to 3 wherein R<sub>2</sub> represents hydrogen, methyl, ethyl, t-butyl, allyl, propargyl, azidoethyl, hydroxyethyl, chloroethyl, dimethylaminoethyl, trimethylammonium-ethyl, 1-carboxyethyl, 2-ethoxycarbonylethyl, phenoxyethyl, benzomidomethyl, t-butylxycarbonylaminomethyl, benzyl (optionally substituted by chloro and or fluoro, or by aminosulphonyl), phenylethyl, pyridylmethyl, pyridylethyl, N-methylpyridinium-methyl, 1,2-oxazolylmethyl, furfuryl, pyridyl, N-methylpyridinium, pyridyl (substituted by 1 or 2 chlorine or bromine atoms, trifluoromethyl, phenyl, or methoxy), N-methyl-2-pyridone, furyl, 2-methylfuryl, thienyl, methylthienyl, N-methylpyrrole, thiadiazolyl, methylthiadiazolyl, uracilyl, N-methyluracilyl, N,N-dimethyluracilyl, cyclohexyl, cyclopropyl, or 4-tetrahydropyranyl, or N-substituted 4-piperidiny.

(5) Compounds as claimed in any of Claims 1 to 4 wherein at least one of R, R<sub>1</sub> or R<sub>2</sub> is other than hydrogen.

5 (6) Compounds as claimed in any of Claims 1 to 5 wherein R<sub>2</sub> represents phenyl (optionally substituted by hydroxy, methoxy, cyano, acetamido or methylsulphonyl), pyridyl, pyridylmethyl, phenoxyethyl, furfuryl or uracilyl.

10 (7) Compounds as claimed in any of Claims 1 to 6 having the following configuration



(8) The compounds

15 (4S,8S,9R,10S,12R)-4-(phenylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

(4S,8S,9R,10S,12R)-4-(3"-pyridineaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

20 (4S,8S,9R,10S,12R)-4-[(2"-hydroxyphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

(4S,8S,9R,10S,12R)-4-[(4"-methylsulphonylphenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

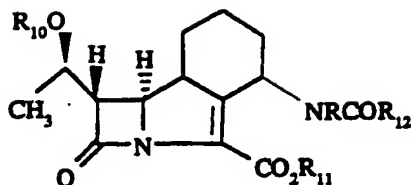
25 (4S,8S,9R,10S,12R)-4-(uracil-5'-amino)carbonylamino-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

(4S,8S,9R,10S,12R)-4-(3"-picolylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

(4S,8S,9R,10S,12R)-4-(2"-furfurylaminocarbonylamino)-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7.2.0.0<sup>3,8</sup>]-undec-2-ene-2-carboxylic acid;

30 (4S,8S,9R,10S,12R)-4-[(2"-methoxyphenylaminocarbonyl)amino]-10-

- (1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- (4S,8S,9R,10S,12R)-4-[(benzylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- 5 (4S,8S,9R,10S,12R)-4-[(3"-cyanophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- (4S,8S,9R,10S,12R)-4-[(2"-phenoxyethylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- 10 (4S,8S,9R,10S,12R)-4-[(4"-acetamidophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- (4S,8S,9R,10S,12R)-4-[(4"-cyanophenylaminocarbonyl)amino]-10-(1'-hydroxyethyl)-11-oxo-1-azatricyclo[7,2,0,0<sup>3</sup>,8]-undec-2-ene-2- carboxylic acid;
- and physiologically acceptable salts and metabolically labile esters thereof.
- 15 (9) Compounds as claimed in any of Claims 1 to 8 for use in therapy.
- (10) The use of a compound as claimed in any of Claims 1 to 8 in the manufacture of medicament for the treatment of systemic or topical bacterial infections.
- 20 (11) A pharmaceutical composition comprising a compound as claimed in any of Claims 1 to 8 in admixture with one or more physiologically acceptable carriers or excipients.
- 25 (12) A method of treatment of a human or non human body to combat bacterial infections comprising administration to said body of an effective amount of a compound as claimed in any of Claims 1 to 8.
- 30 (13) A process for the preparation of compounds as defined in Claim 1 which comprises;
- (a) reacting a compound of formula (II)
- wherein R is as defined in formula (I) and R<sub>10</sub> is a hydrogen atom or a hydroxyl protecting group and R<sub>11</sub> is hydrogen or a carboxyl protecting group and R<sub>12</sub> is an optionally substituted phenoxy or imidazolyl group or halogen atom
- 35

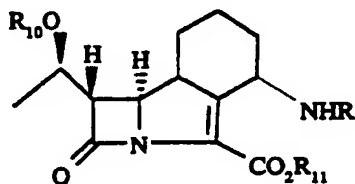


(II)

with an amine (III;  $R_1R_2NH$ ) wherein  $R_1$  and  $R_2$  have the meanings defined in formula (I) or are protected derivatives thereof;

5

- (b) reacting a compound of formula (IV) in which R has the meanings defined in formula (I) and  $R_{10}$  and  $R_{11}$  are as defined in formula (II)



(IV)

10

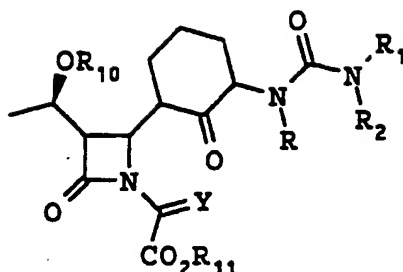


with the isocyanate (V) wherein  $R_2$  has the meanings defined in formula (I) or is a protected derivatives thereof, or the compound (VI) wherein  $R_1$  and  $R_2$  have the meanings defined or are a protected derivative thereof and  $R_{12}$  is an optionally substituted phenoxy or imidazolyl group or halogen;

15

- (c) The preparation of compounds of formula I wherein R and  $R_1$  are  $C_{1-6}$  alkyl by cyclising a compound of formula (VII)

20



(VII)

wherein R, R<sub>1</sub> and R<sub>2</sub> have the meaning defined in formula I or are a protected derivatives thereof with the proviso that R<sub>1</sub> and or R are not hydrogen, R<sub>10</sub> and R<sub>11</sub> are as defined in formula (II), Y is an oxygen atom or a phosphine group; and if required or desired subjecting the resulting compound prior to or subsequent to any separation into its stereochemical isomers, to one or more of the following operations:

- a) removal of one or more protecting groups
- b) conversion of a compound in which R<sub>11</sub> is hydrogen or a carboxyl protecting group into a salt of an inorganic or organic base, an acid addition salt thereof or a metabolically labile ester thereof.



## INTERNATIONAL SEARCH REPORT

Inter. nal Application No

PCT/EP 94/03686

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C07D477/00 A61K31/40

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07D A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,92 15586 (GLAXO S.P.A.) 17 September 1992 see claims ---	1-13
A	EP,A,0 416 953 (GLAXO S.P.A.) 13 March 1991 cited in the application see examples 16-18, 34-36 and claims ---	1-13
A	EP,A,0 507 313 (TAKEDA CHEMICAL INDUSTRIES, LTD.) 7 October 1992 cited in the application see claims -----	1-13

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

13 December 1994

Date of mailing of the international search report

22. 12. 94

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax (+31-70) 340-3016

Authorized officer

Chouly, J

# INTERNATIONAL SEARCH REPORT

Int. application No.

PCT/EP 94/03686

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
Although claim 12 is directed to a method of treatment of (diagnostic method practised on) the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 94/03686

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9215586	17-09-92	AU-A- 1326392	06-10-92
		CA-A- 2104777	08-09-92
		CZ-A- 9301850	13-07-94
		EP-A- 0502468	09-09-92
		EP-A- 0575375	29-12-93
		HU-A- 65134	28-04-94
		JP-T- 6505018	09-06-94
		NO-A- 933170	05-11-93
		NZ-A- 241870	23-12-93
-----			
EP-A-0416953	13-03-91	EP-A- 0416952	13-03-91
		JP-A- 3167187	19-07-91
		JP-A- 3169854	23-07-91
		NO-B- 175479	11-07-94
		US-A- 5138048	11-08-92
		AU-B- 632163	17-12-92
		AU-A- 6226590	14-03-91
-----			
EP-A-0507313	07-10-92	JP-A- 5086062	06-04-93
-----			

**THIS PAGE BLANK (USPTO)**